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COLORADO RIVER BASIN WATER QUALITY CONTROL PROJECT

PROGRAM REVIEW. DENVER, COLORADO
APRIL 25, 1966

FEDERAL WATER POLLUTION CONTROL ADMINISTRATION
DENVER, COLORADO

APRIL 1966

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PROGRAM REVIEW

COLORADO RIVER BASIN WATER QUALITY CONTROL PROJECT

DENVER, COLORADO
APRIL 25, 1966

U. S. DEPARTMENT OF
HEALTH, EDUCATION, AND WELFARE
Federal Water Pollution Control Administration
REGION VIII – DENVER, COLO.

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The Colorado River Basin Water Quality Control Project is reviewed. The bulk of this report deals with activities and accomplishments for FY 1966, including: radiological pollution; mineral pollution; municipal, industrial, and related water pollution problems; laboratory activities; and STORET activities. Departures from FY 1966 Plans are reviewed along with plans and schedules for work proposed for FY 1967. Details are also offered on the budget justification, technical backup requirements, and organization and management.

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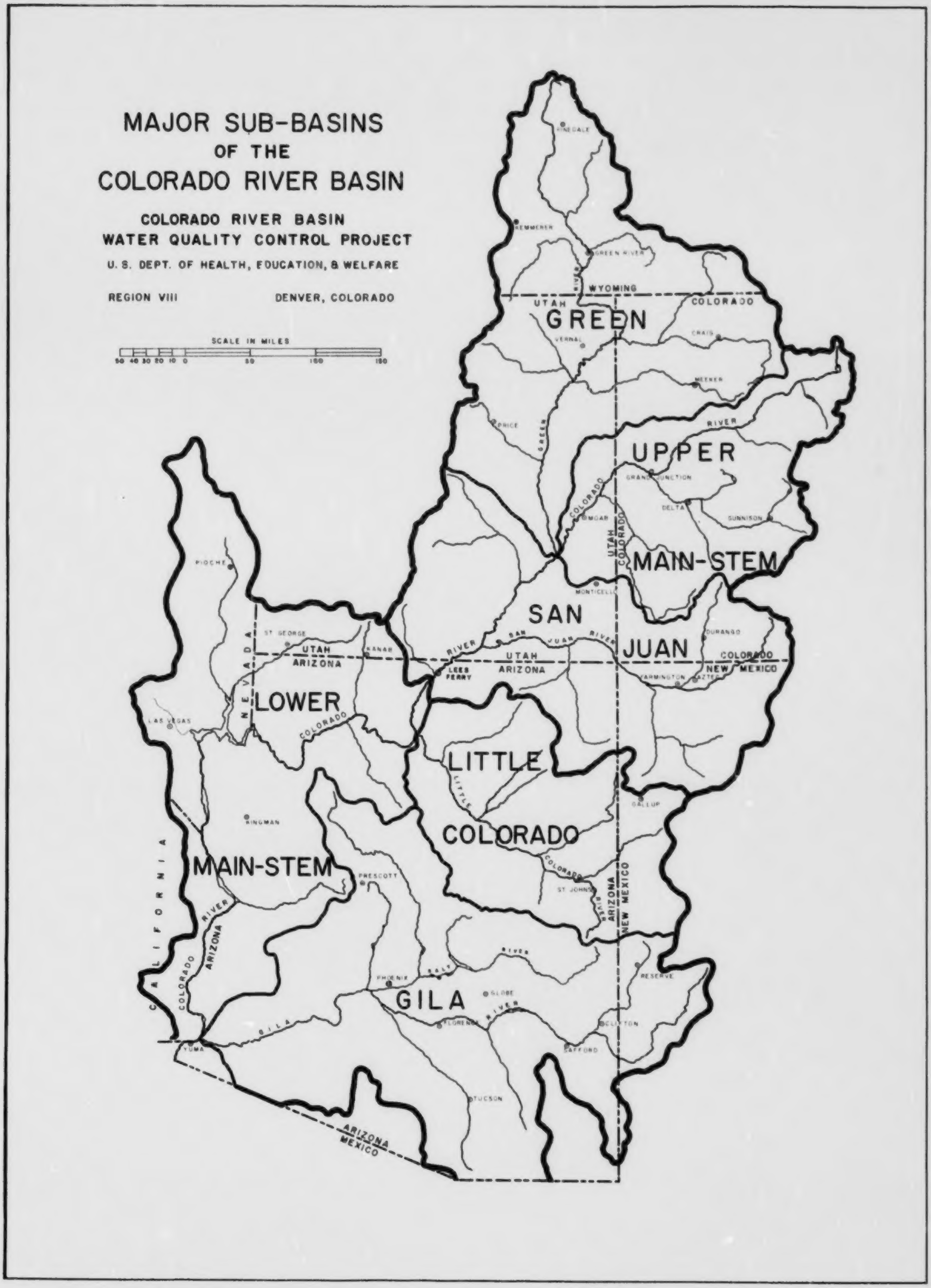

MAJOR SUB-BASINS OF THE COLORADO RIVER BASIN

COLORADO RIVER BASIN
WATER QUALITY CONTROL PROJECT
U. S. DEPT. OF HEALTH, EDUCATION, & WELFARE
REGION VIII DENVER, COLORADO

SCALE IN MILES
50 40 30 20 10 0 50 100 150
GREEN
UPPER
MAIN-STEM
SAN
JUAN
LOWER
MAIN-STEM
LITTLE
COLORADO
GILA
WYOMING
UTAH
COLORADO
NEVADA
ARIZONA
NEW MEXICO
CALIFORNIA
MEXICO
PINEDALE
KEMMERER
GREEN RIVER
VERNAL
CRAIG
MEEKER
PRICE
GRAND JUNCTION
DELTA
GUNNISON
MOAB
MONTICELLO
DURANGO
FARMINGTON
AZTEC
PIOCHE
ST. GEORGE
KANAB
LEES FERRY
LAS VEGAS
KINGMAN
PRESCOTT
GALLUP
ST. JOHNS
PHOENIX
GLOBE
FLORENCE
SAFFORD
CLIFTON
RESERVE
TUCSON
YUMA
RIVER
SAN JUAN RIVER
SALT RIVER
GILA RIVER
LITTLE COLORADO

PROGRAM REVIEW

COLORADO RIVER BASIN WATER QUALITY CONTROL PROJECT

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U. S. Department of Health, Education, and Welfare
Federal Water Pollution Control Administration
Region VIII

Colorado River Basin Water Quality Control Project
Denver, Colorado

April 1966

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PROJECT FACTS

NAME OF PROJECT: Colorado River Basin Water Quality Control Project

GEOGRAPHICAL AREA OF RESPONSIBILITY: Entire Colorado River Basin and its water service area of southern Colorado; includes portions of Arizona, California, Colorado, Nevada, New Mexico, Utah, Wyoming.

LOCATION OF PROJECT OFFICES:

Headquarters
Room 415, Building 22
Denver Federal Center
Denver, Colorado 80225

FTS 303/233-3611 Extension 8128

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M. B. Rainey, Deputy Project Director

Field Station
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Phoenix, Arizona 85004

FTS 602/261-3871

W. C. Blackman, Jr., Chief

Field Depot
Bldg. 26, AEC Compound
Grand Junction, Colorado

FTS 303/242-8374

Laboratory
1750 S. Redwood Road
Salt Lake City, Utah 84104

FTS 801/524-5290

D. E. Rushing, Director

DATE PROJECT AUTHORIZED: Fiscal Year 1960; Started January 1960.

DATE FIELD STATIONS OPENED:

Salt Lake City Laboratory - FY 1961
July 1, 1960 first personnel
January 1961 first limited operation
May 1962 full operation
Phoenix Field Station - FY 1964
August 1963
Grand Junction Field Depot - FY 1965
March 1965

PROJECT BUDGET AND POSITIONS:

FY	1960	1961	1962	1963	1964	1965	1966	1967
Budget: ($100)	80	400	492	730	580	685	672	637
Positions authorized:	13	43	48	52	49	49	52	52
Filled:	-	23	41	40	41	44	52	52

SECTION A
PROJECT PROGRAM

Framework Studies

BACKGROUND INFORMATION

The Colorado River Basin Water Quality Control Project was established as a result of recommendations made at the first session of a joint Federal-state "Conference in the Matter of Pollution of the Interstate Waters of the Colorado River and Its Tributaries" held at Phoenix, Arizona, in January 1960 under the authority of Section 8 of the Federal Water Pollution Control Act (33 U. S. C. 466 et. seq.). This conference was called at the request of the States of Arizona, California, Colorado, Nevada, New Mexico, and Utah to consider water pollution problems in the Colorado River and its tributaries.

Long-Range Goal and Objectives

The long-range goal of the Colorado River Basin Water Quality Control Project is the improvement of water quality in the Colorado River Basin and its water service area in southern California. In working toward this goal, the Project is undertaking field investigations, together with engineering and economic studies to accomplish the following objectives:

(1) To determine the location, magnitude, nature, and causes of interstate pollution of the Colorado River and its tributaries.

(2) To determine and evaluate the nature and magnitude of the damages to water users caused by radioactivity, salinity, and other types of pollution.

(3) To develop and evaluate methods for controlling or minimizing this pollution.

(4) To recommend control or other measures justified by benefits,

economic or otherwise, that will accrue from improved water quality.

Upon completion of activities for accomplishing these objectives, a detailed report covering all field and laboratory investigations, engineering and economic studies together with recommended water quality control programs and measures, will be submitted to the conferees for further action as required under the enforcement provisions of the Federal Water Pollution Control Act.

An important adjunct to the long-range goal of improvement of water quality in the Basin is the fact that the data obtained by the Project will be invaluable to the seven basin states in the development of water quality standards as set forth in the Water Quality Act of 1965. In addition, Project data will be valuable in connection with the prevention, control, and abatement of water pollution by Federal activities within the Basin as required under Presidential order 11258.

Program for Achieving Long-Range Goal and Project Objectives

The Project serves as the technical arm of the conference and provides the conferees with detailed information on water uses, nature and extent of pollutants, their effects on water users, and recommended control measures for improving water quality in the Colorado River Basin. Through the regular formal sessions of the conference and informal technical meetings with the conferees, priorities are established for attacking the Basin's pollution problems and maximum utilization can be made of the Project's technical data and recommendations. In instances where identifiable pollution sources can be readily controlled or eliminated through the efforts of the state water pollution control agencies or other organizations, firm recommendations for control of such pollution are made during the course of the Project. To date, five formal sessions of the conference have been held to evaluate the Project's technical data, control recommendations, and the progress which has been made in reducing pollution in the Basin.

Initially, the conferees emphasized the need for control of the radiological pollution problems associated with the uranium milling industry in the Colorado River Basin. When adequate data had been obtained by the Project to show that uranium milling wastes were indeed creating a radiological pollution problem, a comprehensive program of pollution abatement was voluntarily undertaken by the uranium milling industry in cooperation with state and Federal agencies. This abatement program, consisting of treatment and containment of milling waste products, has been highly successful in reducing radioactive discharges to Basin streams. Thus, current radioactivity levels in surface waters of the Basin are well below recommended limits.

The reduction in uranium production after 1960, and the closing of a number of uranium mills in the Basin raised some additional questions for consideration by industry, the conferees, the Project, state and Federal agencies. These questions concern the long-term responsibility and control measures for the large quantities of solid wastes, or tailings piles at the closed mills. Much of the radioactivity contained in the tailings piles is very long-lived. At a number of mill locations, the tailings piles are subject to slow erosion by wind and water to nearby streams. While the slow erosion of tailings piles into Basin streams will not produce large scale contamination, there is potential for small continuous amounts of radioactivity to be leached to the streams over a long period of time.

In view of this potential for radiological contamination of Basin waters, the conferees at the Fifth Session of the Conference held in Las Vegas, Nevada, on May 26, 1964 directed the Project to prepare a detailed report on the disposition and control of uranium tailings piles. This report has been prepared and submitted to the conferees and representatives of the Atomic Energy Commission and U. S. Public Health Service for comment. The final report, which was released in March 1966, provides detailed information on the nature and extent of the uranium mill tailings problem, discusses the long-term potential for water contamination, and suggests possible control measures together with estimates of their approximate costs. It is anticipated that the Project report, together with the studies being carried out by industry and various state and Federal agencies, will be of value in developing a satisfactory solution to the uranium mill tailings problem. A great deal of news coverage was generated by the publication of this report. It would be fair to state that industry reaction generally was significant. The State of Colorado has also reacted through the proposed establishment of a state health regulation to control these piles (see copy of proposed regulation - Appendix A).

The radiochemical surveillance program stemming from previous studies is being continued by the Project to provide current data on radiological pollution in the Basin and insure protection of downstream water users.

At the third session of the conference, held in 1963, the direction of the Project's investigations was shifted to mineral pollution, commonly known as salinity, a problem that is becoming increasingly important to users of Colorado River water. Since that time, a major portion of the Project's effort has been devoted to the salinity problem. The Project is attacking the mineral pollution problem through a program combining engineering and economics.

The engineering activities are directed toward the identification and evaluation of the sources of saline pollution, the assessment of damages to water users resulting from saline pollution, and the development of feasible measures for controlling or minimizing saline pollution, whether it be from agricultural, municipal, industrial or natural sources.

In the economic studies, the level and pattern of economic activity in the Basin is being projected for the years 1965, 1980, and 2010. Interindustry input-output tables have been prepared for each subbasin for each of the target years. An analysis of water quantity and quality as constraints on the level and pattern of economic activity is also being made for these years. It is expected that the study of the relation of benefits to costs, based upon present and projected future water quality resulting from various combinations of programs for control of salinity sources may be an integral element in merging the engineering and economic data. In the economic and engineering projections for the years 1980 and 2010 full cognizance will be taken of changes decreed by the U. S. Supreme Court's allocation of Colorado River water and the proposed development of water resource projects by the various construction agencies.

In addition to its regular staff, the Project has technical expertise available to it through its economic contractors, the University of Colorado and the Economic Research Service of the U. S. Department of Agriculture, which are making an economic study of the Colorado River Basin. Special technical assistance in biological, bacteriological, organic, and related sciences is available to the Project from the Robert A. Taft Sanitary Engineering Center in Cincinnati, Ohio. Another resource now developing and available to the Project is the technical assistance and research capability at the Robert S. Kerr Water Research Center in Ada, Oklahoma.

The Project is attacking the pollution problem in the Colorado River Basin with a staff of about 50 employees having capabilities and expertise in many fields. Civil and sanitary engineers, hydrologists, geologists, economists, radiochemists, and analytical chemists make up the professional segment of the staff. In a supporting role are the administrative and clerical staffs, and the engineering aides, instrument technicians, laboratory aides, and aquatic samplers.

The fact that the Project has devoted major attention to radiological and mineral pollution has not precluded concern for other types of pollution in the Basin. During the past two years, a continuing effort has been made to identify other waste sources including municipal, industrial, mining, and allied activities. Project personnel have observed unsatisfactory waste effluents being discharged from both municipal and industrial sources to various streams in the Basin with subsequent downstream degradation in water quality. In some streams the state fish and game departments have discontinued fish stocking because toxic and other wastes discharged to the waters will not permit aquatic life to exist. Municipal and industrial pollution has affected other water uses in certain areas of the Basin. These pollution problems were discussed at a public progress meeting held in Grand Junction, Colorado, on December 13, 1965. At this meeting it was recognized that additional current data were needed to support the abatement of these problems in order to meet overall Project objectives.

The Project has developed detailed studies for the identification, evaluation, and control of municipal, industrial, and nutrient pollution of the surface waters of the basins. These studies are being carried out in close cooperation with personnel from the Robert A. Taft Sanitary Engineering Center in Cincinnati, Ohio, and the state water pollution control agencies. The data obtained from these investigations will be utilized in determining the measures and programs needed for controlling or minimizing municipal, industrial, and nutrient pollution. Recommended time schedules for the control of municipal and industrial pollution will be developed in cooperation with the appropriate state water pollution control agencies.

It is anticipated that all major Project investigations pertaining to the pollution of the interstate waters of the Colorado River and its tributaries will be completed by the end of FY 1967. The preparation of the final Project report should also be well under way at that time. It is anticipated that the final report covering all aspects of Project activities, including field and laboratory investigations, engineering and economic studies, together with recommended water quality con[illegible]ograms, can be completed and submitted to the conferees by the mi[illegible] of FY 1968.

CONSULTANTS AND COMMITTEES

Consultants

It is anticipated the following persons will be used as consultants during Fiscal Year 1966:

1. Dr. William Miernyk, Director, Regional Research Institute, University of West Virginia, Morgantown, West Virginia.

   Dr. Miernyk's services will be obtained through the Project's economic contractor, the University of Colorado. Dr. Miernyk will review and critically analyze the application of the engineering-economic model to the Colorado River Basin. He will offer suggestions for any adjustment in procedures which appear to be necessary.

2. Mr. Blair T. Bower, Associate Director, Quality of the Environment Program, Resources for the Future, Inc., Washington, D. C.

   Mr. Bower's services will be obtained through the Project's economic contractor, the University of Colorado. His services to the Project will comprise advice on such problems as the methodology of estimating the economic effects of water pollution; on the utilization of an input-output model in projecting economic activities and their associated water demand; on the conversion of economic data, expressed in monetary values to specific units of industrial output; and on procedures for determining the optimum economic level of water quality in a water resources system.

3. Dr. E. C. Tsivoglou, Officer in Charge, Physical and Engineering Sciences, Field Operations Activity, Technical Services Program, Federal Water Pollution Control Administration, Cincinnati, Ohio.

   Dr. Tsivoglou's services to the Project consist of advice and recommendations concerning the current radiological surveillance program in order to coordinate these investigations with earlier studies in the field of stream pollution resulting from waste discharges by the uranium mining and milling industry. This advice includes suggestions on methods and frequency of sampling of uranium milling effluents and radioactivity carrying media in streams, and recommendations for the investigation of the problem of ultimate disposition of uranium mill tailings pile material, and on methods of interpreting radiological data.

Technical Committees

Technical Review Panel

This panel is comprised of the following persons:

1. Mr. Raymond Hill, Leeds, Hill, and Jewett, of San Francisco, California.
2. Dr. Vaughn Hansen, Director, Water Resources Laboratory, Utah State University, Logan, Utah.
3. Mr. Blair T. Bower, Associate Director, Quality of the Environment Program, Resources for the Future, Inc., Washington, D. C.

This panel is charged with the responsibility for reviewing specific technical procedures and methodology employed by the Colorado River Basin Water Quality Control Project in its analysis of the effects on the beneficial uses of water through changes in water quality of the Colorado River.

Ad hoc Committee on Water Quality Objectives

The committee is comprised of the following persons:

1. Mr. Paul Bonderson, Executive Director, California State Water Quality Control Board, Sacramento, California.
2. Mr. W. W. White, Director of Health and Welfare, State of Nevada, Carson City, Nevada.

3. Mr. Lynn M. Thatcher, Director, Division of Environmental Health, Utah State Department of Health, Salt Lake City, Utah.
4. Mr. L. M. Klashman, Regional Program Director, Federal Water Pollution Control Administration, Department of Health, Education, and Welfare.
5. Mr. J. M. Rademacher, Director, Colorado River Basin Water Quality Control Project, Denver, Colorado.

This committee is considering water quality objectives for the interstate segments of the Colorado River and its tributaries. The guidelines developed should provide a basis for the various Basin states to establish water quality criteria in conformance with the provisions of the Federal Water Quality Act of 1965.

Ad hoc Committee on Oil Field and Oil Transmission Line Pollution Problems. -- The formation of this committee was requested at the Grand Junction progress meeting on December 13, 1965. Mr. Arthur E. Williamson, Director, Division of Environmental Sanitation, Wyoming Department of Public Health, was named as chairman. A Project staff member and representatives from the oil producing and transmission industries are expected to participate in developing approaches to minimize pollution by accidental spills from oil field and transmission line operations.

Technical Review by Federal-State Conferees. -- An annual review of technical progress is made by the Federal and state conferees.

ACTIVITIES AND ACCOMPLISHMENTS - FY 1966

General

Fiscal Year 1966 has seen some significant advances in progress by the Colorado River Basin Water Quality Control Project. The radiological pollution problems have resolved themselves to a surveillance and cleanup operation. Tailings piles from these operations have been pinpointed as long-term potential hazards and a concerted drive is underway to have the industry accept its responsibility to control these potential sources of pollution.

The source identification program for salinity is reaching its final phase with completion of the intensive field operations scheduled for the end of this fiscal year. A monitoring program consistent with enforcement needs and for water quality standards development is being planned.

A statistical study of existing water quality data has been completed and a specific constituent analysis is well underway.

Assessment of salinity damages for the significant water uses in the Colorado River Basin and its tributary areas is on schedule and will be completed this fiscal year. The derivation of the value of irrigation water for specified areas was an important development in connection with the salinity damage assessment program. Preliminary reports have been prepared for control of discrete natural sources in the Colorado River Basin and preliminary evaluations have been made of certain concentrating factors such as, reservoir evaporation, phreatophytes, and exports.

The economic studies concerning salinity have made major advances during the year with the most significant progress being the development of the methodology for merging engineering and economic data. A trial run of the methodology has been made for the Lower Main Stem Subbasin with relatively few procedural problems developing.

In the past, the effects of municipal and industrial pollution were given limited consideration by the Project. Recent field surveys have identified many streams which have been significantly affected by such pollution. The Project is undertaking a basin-wide survey program which should be helpful to the conferees and to the states in developing a meaningful stream standards program. Similarly, investigations on the potential of nutrient pollution in the Basin, Federal installations, oil pipelines and oil fields are receiving important consideration by the Project.

A very important development during the year was the request made by the Bureau of Reclamation, Region III office in Boulder City, Nevada, to provide guidelines in the establishment of water quality standards for Las Vegas Wash as part of the repayment contract for the Southern Nevada Water Supply Project which will provide the Las Vegas-Henderson area with some 300,000 a.f. of water from Lake Mead. The major concern of the Bureau is the nutrient contribution to Lake Mead and its effect on water uses.

A Project progress meeting was held in Grand Junction, Colorado, on December 13, 1965. The specific problems associated with municipal and industrial wastes and the uranium mill tailings piles were the primary subjects for review. Major news coverage was received and much support developed for our program from such sources as the Department of Interior and the conservation groups. Specifically, the Department of Interior regional coordinator believed that this was a major demonstration of our interest in cleaning up the more conventional types of pollution and would result in a better understanding with the agencies he represented.

The Project Activity Sequence Diagram still reflects Project program. However, the time scale has shifted to the right due to personnel lapses and delays caused by the unsettling administrative problems during the past year. In addition, the increased attention to municipal and industrial wastes and our possible role in the water quality standards program necessitates an extension of six months to mid-FY 1968 before completion of the final report is accomplished.

From an organizational standpoint, the Project has a new face. The fragmented structure for engineering studies which was originally set up has given way to a single activity, the Pollution Damage and Control Section. This has provided the Project with flexibility in use of personnel which the previous structure prevented. We further expect to improve the organizational response when the Pollution Source and Evaluation Section is brought to Denver from Phoenix. This transfer is scheduled for June of this fiscal year.

The outline of the final Project report is in draft form. A copy has been included in Appendix B. Preliminary drafts of significant sections have been prepared and others are underway. In anticipation of personnel losses, the section dealing with radioactivity is scheduled for completion during this fiscal year.

A more complete report on activities and accomplishments follows.

Radiological Pollution

Stream surveillance and control of uranium mill tailings piles are the two major responsibilities of the Project with respect to radiological pollution. The completion of the Project report, "Disposition and Control of Uranium Mill Tailings Piles in the Colorado River Basin," which was issued in March 1966, marked a significant step in coming to grips with this long-term potential hazard. Specifically, the report recommended the following actions be taken regarding the tailings piles:

1. That interim measures to prevent the erosion and spread of uranium mill tailings piles be undertaken without undue delay.

2. That all distribution of mill tailings from either nonoperating or operating mills be halted until proper and adequate precautionary review procedures can be instituted.

3. That discussions be held and binding agreements be reached as soon as possible regarding long-term public and private responsibility for adequate maintenance of the tailings piles.

The various state Conferees all submitted letter of concurrence with the report prior to its public issuance. The Atomic Energy Commission was skeptical and only agreed to the lack of "immediate hazard" and specifically stated their lack of authority under present regulations.

The mill operators for the most part have instituted preliminary engineering surveys to develop controls for the piles. Apparently, the Union Carbide Nuclear Corporation is leading the way with immediate plans for developing controls at the closed Slick Rock mill and at Rifle. It would be fair to state that a certain amount of recrimination by the mill operators has resulted from the extensive news coverage on the subject. However, this exposure to the public eye has resulted in the mill operators moving toward solutions to the problem.

Surveillance will play a continuing role in the Federal Water Pollution Control Administration's activity in the Colorado River Basin. The uranium industry is at a nadir in its operations, but strong indications of heavy demands for atomic fuel in the future presage a rebirth of mining and milling operations. The present monitoring program involving 21 sampling stations in the Basin should provide the necessary control. In addition, our radiological consultant, Dr. Tsivoglou, strongly recommends the continuance of the annual sediment surveys, the last of which was completed in March 1966.

The radiological segment of the final Project report is in preparation. Review drafts of this report should be available by the end of FY 1966.

Mineral Pollution (Salinity)

Source Identification and Evaluation (Phoenix Field Station)

Field Activities.--The salinity sampling program and the intensive surveys for salinity in the Upper Basin will be completed in June 1966. This will permit the identification and evaluation of natural, municipal, industrial, and agricultural sources of mineral pollution throughout the entire Basin.

Much staff time was devoted to the development of data handling systems by which the mass of accumulated quality data is to be processed. They include a field data form on which the sampler records all pertinent field data. A copy of this form goes directly to a keypunch operator for the punching of field data on STORET cards. A simplified method of recording laboratory data also permits direct free-form punching of the analytical results on STORET cards. Computer programs have been developed and are in use, which permit calculation and printout of loads and flow-weighted monthly mean.

A data release program was developed to permit the dissemination of raw chemical quality data to the Conferees and cooperating agencies. This program also utilizes the STORET cards without the necessity for supplemental key punching or data handling. A complete data release for the Lower Main Stem and quarterly data releases for the Upper Basin were provided during the year.

The Project entered into an agreement whereby the U. S. Geological Survey established nonrecording gages at 13 stream sampling sites in the Upper Basin. The U. S. Geological Survey made sufficient numbers of flow measurements at each of these sites to permit construction of rating curves.

RSQD Conductivity Recorders were deployed at many sampling sites and much staff time was devoted to the solution of the inherent operational shortcomings of the systems. Programs were developed to translate punch-tape data from the systems into punched cards, thence, to printouts having daily and period means, and standard deviations calculated thereon. In November it was discovered that the systems were badly affected by ambient temperature changes. Accordingly, after tests by field station personnel and the SEC Instrument Consultant, two of the systems were returned to the manufacturer for major redesign work. The remaining eight systems have been shelved and further Project investment is planned at this time.

In the course of reconnaissance and sampling work on discrete salinity sources, several cases in which brine produced in oil field malpractice, or by abandoned oil test holes, were discovered and brought to the attention of appropriate regulatory agencies in the states concerned. In most cases such pollution has been stopped.

Narrative reports summarizing the geology, geomorphology, and ground-water hydrology of each of the twenty-nine intensive survey areas in the Upper Basin have been prepared. Reconnaissance work revealed many discrete natural sources about which the literature presented incorrect or inconclusive information, or which are not mentioned in the literature. Some of these appear to be amenable to control. The field station staff assisted the U. S. Geological Survey in the collection of samples to be utilized in studies of overland runoff.

Statistical Study of Historical Quality Data.--A report entitled, "Statistical Analysis of Existing Water Quality Data - Colorado River Basin," was completed. Work was in progress on the calculations for this report at the time of the last Program Review. Shortly thereafter, it was found that the statistical methods which were utilized in the analysis of the Lower Main Stem data were not applicable to the Upper Basin data. Also, much of the Upper Basin data were found to be not normally distributed. Accordingly, a much greater investment in staff time was necessary in order to complete the report. Briefly, the methods utilized included separation of the high flow "runoff" months, and the low flow or "base flow" months. Each group was then analyzed separately. It was also necessary to resort to nonparametric methods for some of the analyses. Fifteen quality stations in the Basin were found to have had significant changes in the base flow months. Four stations demonstrated increases in TDS concentrations, five experienced decreases, and the remaining six demonstrated periods of both increased and decreased salinity concentrations. In the runoff months, only five stations had significant changes, and all five were increases in mean TDS concentration.

Statistical Study of Specific Constituents.--Each of the professional staff made separate detailed reviews of U. S. Geological Survey Professional Paper No. 441, better known as the "Iorns Report." Subsequent to these reviews, work was begun on a constituent analysis utilizing actual and synthetic data for water years prior to 1957 from the report, and actual data for the years since 1957. The product of this work will be duration curves for the principal mineral constituents at approximately thirty-five stream sampling stations in the Basin. Data after 1957 are not available for ten of these stations. Additionally, the calcium, magnesium, sodium, and potassium values since 1957 are not comparable to the prior data and thus cannot be included in the analysis. In connection with this activity, much staff time was devoted to the proofing and correcting of the 20,000 ADP cards which the Project had punched in 1963.

Damage Assessment

Salinity and hardness in water supplies cause additional costs to water users, whether in agriculture, industry, or domestic service. These costs are referred to as damages or penalty costs, and are of many different kinds; for example, one authority has identified not less than 13 different water quality damage effects in irrigation, although to be sure not all of these are independent. Likewise there are a number of detrimental consequences of salinity and hardness in industrial and domestic water supply. While these effects are generally recognized it is not always possible to quantify their relationship to differences in water quality. The Project staff have therefore confined their attentions to the following types of water quality penalty costs:

Irrigated agriculture	(1)	Additional requirement of leaching water to maintain salt balance in croplands;
	(2)	The additional labor cost to apply that leaching water;
	(3)	Construction and maintenance of new or improved land drainage facilities;
	(4)	Waste of applied inorganic fertilizers by leaching;
Industry	(1)	Extra requirement of makeup water in boiler feed and in recirculating cooling and condensing systems;
	(2)	The incremental cost of treatment of the above water.

Domestic	(1) The incremental cost of softening, whether in central publicly-owned plants, or in privately-owned water softeners; (2) The wastage of soaps and detergents consequent on a harder water supply.

The methodology used in assessing the penalty costs listed was described in pages 4-8 of our 1965 Program Review document.

The Project staff have also examined the effects of mineralization in the replenishment of ground waters. While in general it has not been possible to equate water quality with specific economic costs in this use of water, the work does serve to direct attention to the harmful physical results which may be associated with employment of poor water in recharge of underground basins. In addition, this study assesses the likelihood of occurrence of this water quality problem, and its relative severity in each of the three principal regions of water demand.

The term damages or penalty costs is meaningless except in relation to some basis of reference. Damages represent the incremental or extra cost of water users, compared with water costs for some previous condition of water quality. These water quality bases are two in number: the pristine or virgin condition, existing prior to any economic development, and the present quality, computed from actual records of the three years 1962-1964. The pristine quality is of course a synthetic or calculated value, and has been taken from authoritative published reports of a sister agency, the U. S. Geological Survey.

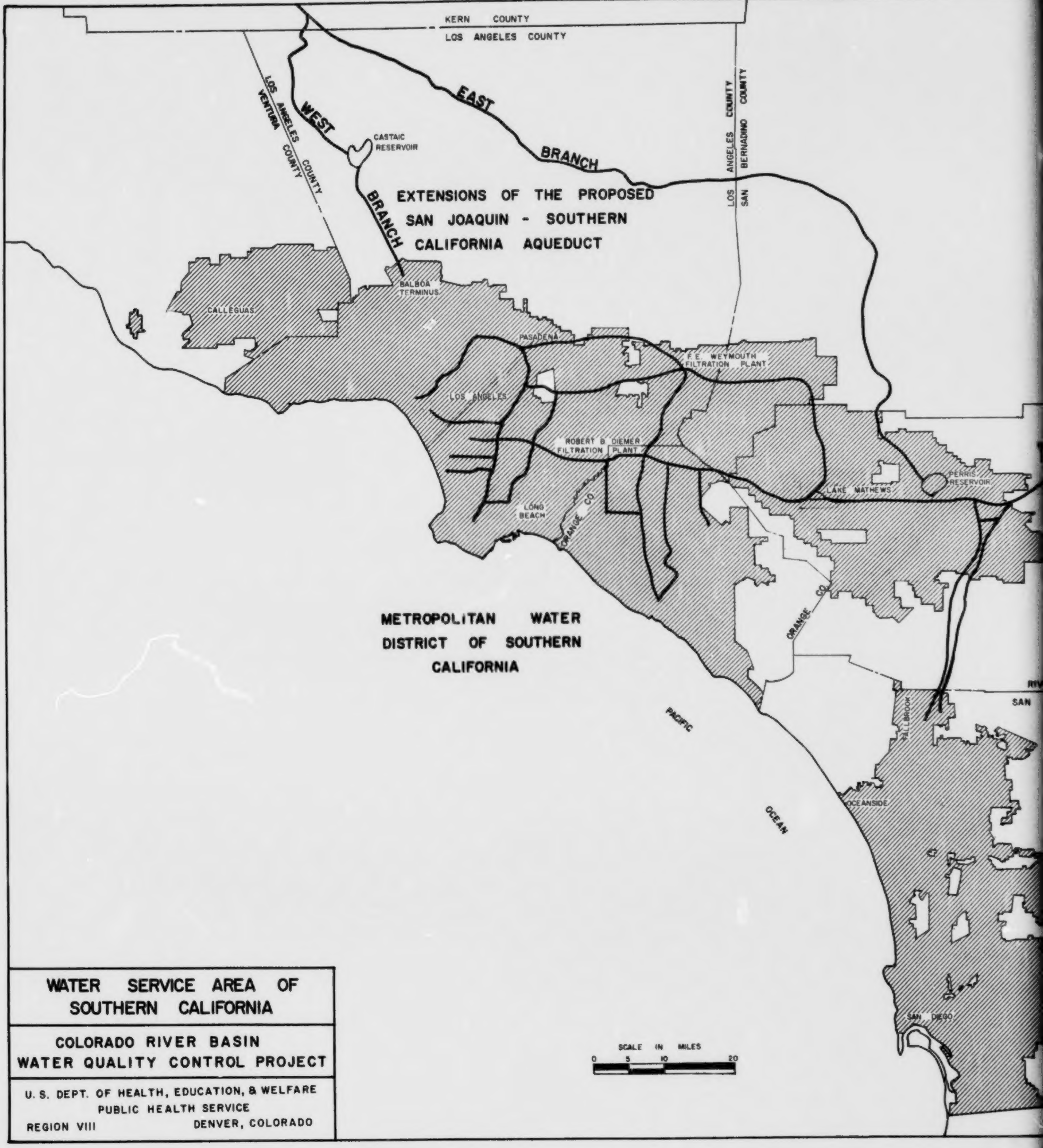
Water costs at the aforesaid base levels of quality are compared with those which would occur at projected future quality levels. (In practice the staff have dealt generally with cost increments or differentials rather than absolute values).

Preliminary projections of future water quality have been obtained from two respected sources, the Bureau of Reclamation (USBR) and the engineering firm of Leeds, Hill and Jewett, Inc. (LHJ) of Los Angeles, California. In each case the estimates have been prepared with full consideration to the effect of future developments. USBR have calculated the mean annual quality which will prevail at selected river stations after completion of each of five groups of water resources projects. They take into account the effects on present levels of water quality caused by consumptive losses of water, as well as by future changes in the total salt burden, under a predetermined pattern of reservoir operation. The water quality projections prepared by Leeds, Hill and Jewett have been made by considering the effects on present quality of (1) future depletions of water by consumptive use in the Upper Basin states; (2) reservoir evaporation; (3) transmountain exports of water from Colorado River Basin; and (4) new mining, industrial and commercial developments in the Upper Basin which will support an estimated additional population of one million persons.

In addition to the projections of future water quality described above, the Project will develop independent estimates of water quality from projections of economic activity to be furnished by the Economic Contractor. A mathematical technique for doing this has been worked out by the Project staff. The Project's estimates of future water quality in turn will be used to compute a new and definitive value of the direct penalty costs of higher hardness and salinity in water supplies of the Basin.

In the assessment of salinity and hardness damages, main attention of the staff has focused in the Lower Basin of the Colorado and in those areas of southern California served with a Colorado River water supply. There are two principal reasons for this. First, the economic development and water use in the downstream areas are vastly greater than those above Lee Ferry; about 97 percent of the population, and two-thirds or more of the water use occur below Lee Ferry. Second, as in all heavily used river systems, the water quality problems are more severe in the lower reaches. The salinity of the Colorado River, in fact, increases about tenfold between its headwaters and the Imperial Dam above Yuma. Since the populous Lower Basin areas are those which receive the poor water from the Colorado, it is there rather than in the Upper Basin that one should look first for evidence of the economic penalties of a mineralized water supply. The Lower Basin areas of concern are three: the subbasin of the Lower Main Stem of the Colorado, the area to be served by the Central Arizona Project, and the southern California water service area, which comprises territories of the Metropolitan Water District of Southern California, the Imperial Irrigation District, and the Coachella Valley County Water District (please see maps).

Although the principal damage effects evidently are in the Lower Basin, Upper Basin areas have not been overlooked, and an appraisal of damages has been made in two major areas where a deterioration in water quality has been forecasted: the upper valley of the San Juan River in New Mexico, and the Duchesne River Basin in Utah.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EAST BRANCH
CASTAIC RESERVOIR
EXTENSIONS OF THE PROPOSED SAN JOAQUIN - SOUTHERN CALIFORNIA AQUEDUCT
BALBOA TERMINUS
CALLEGUAS
PASADENA
F. E. WEYMOUTH FILTRATION PLANT
LOS ANGELES
ROBERT B. DIEMER FILTRATION PLANT
LONG BEACH
ORANGE CO.
ORANGE CO.
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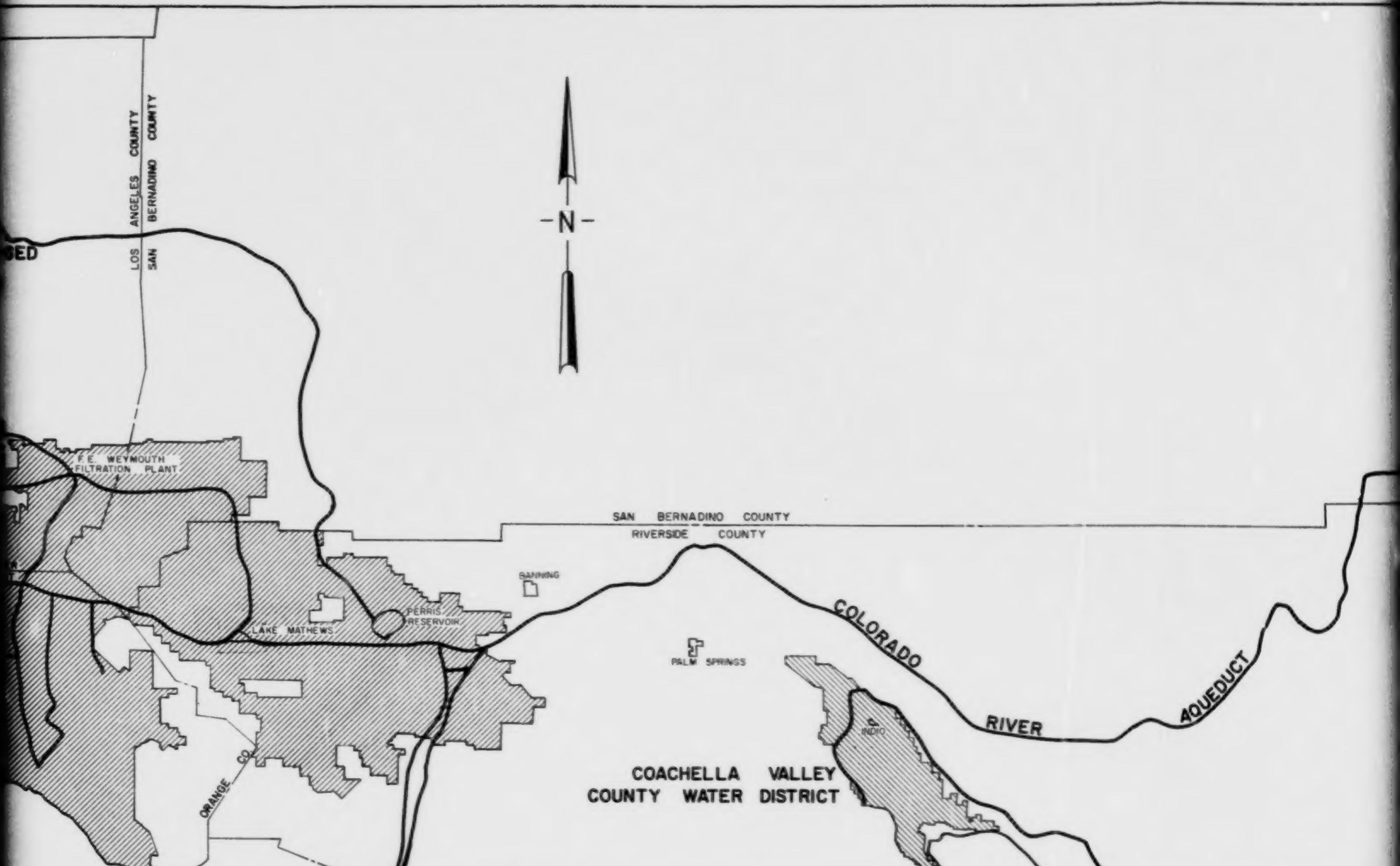
WATER SERVICE AREA OF SOUTHERN CALIFORNIA

COLORADO RIVER BASIN
WATER QUALITY CONTROL PROJECT

U. S. DEPT. OF HEALTH, EDUCATION, & WELFARE
PUBLIC HEALTH SERVICE
REGION VIII DENVER, COLORADO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PALM SPRINGS
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INDIO
COACHELLA VALLEY COUNTY WATER DISTRICT
ORANGE CO
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SAN DIEGO COUNTY
RIVERSIDE COUNTY
IMPERIAL COUNTY
PACIFIC OCEAN
FALLBROOK
SALTON SEA
COACHELLA CANAL
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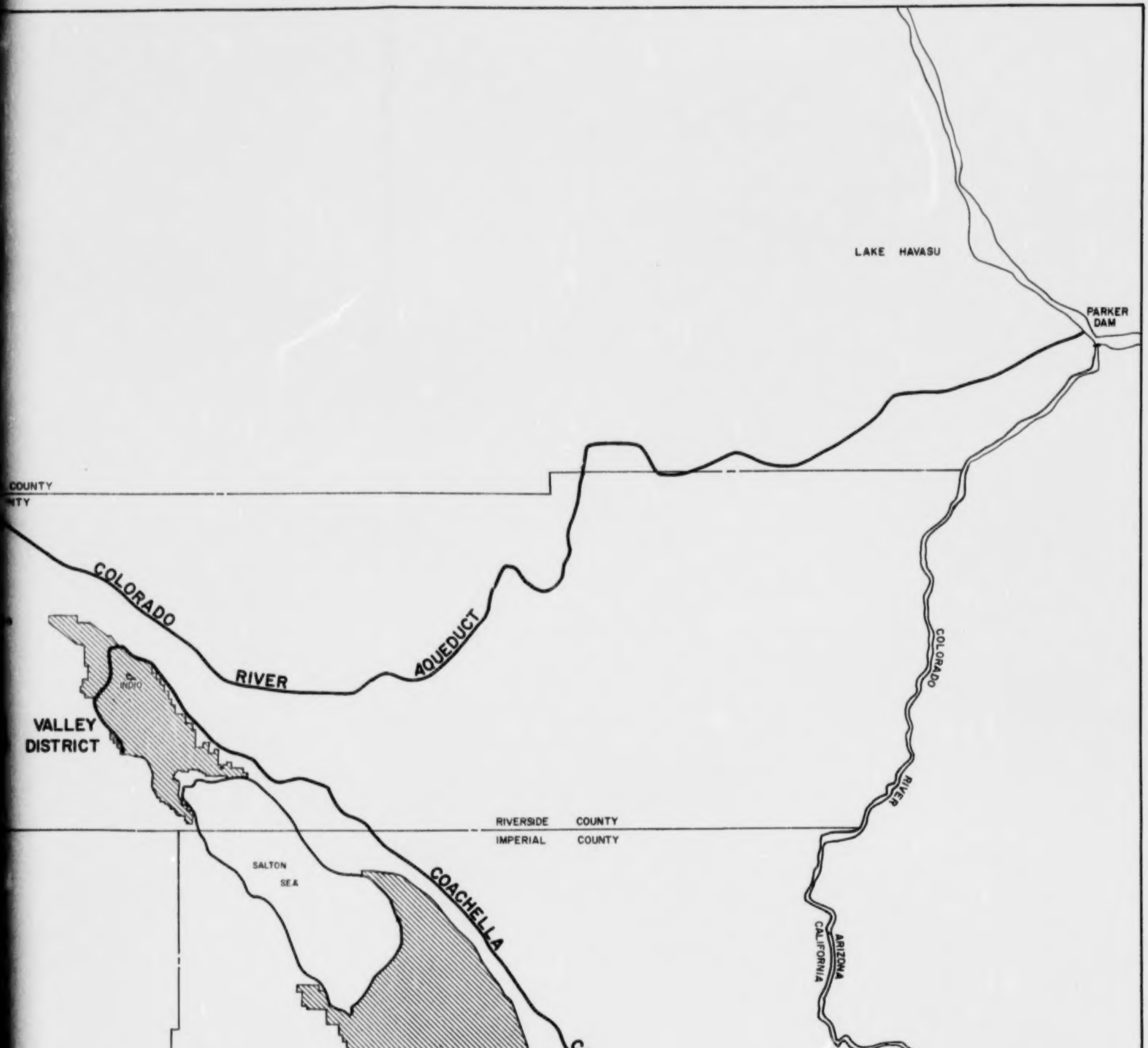
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COACHELLA CANAL
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BRAWLEY
IMPERIAL IRRIGATION DISTRICT
IMPERIAL RESERVOIR
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SAN DIEGO COUNTY
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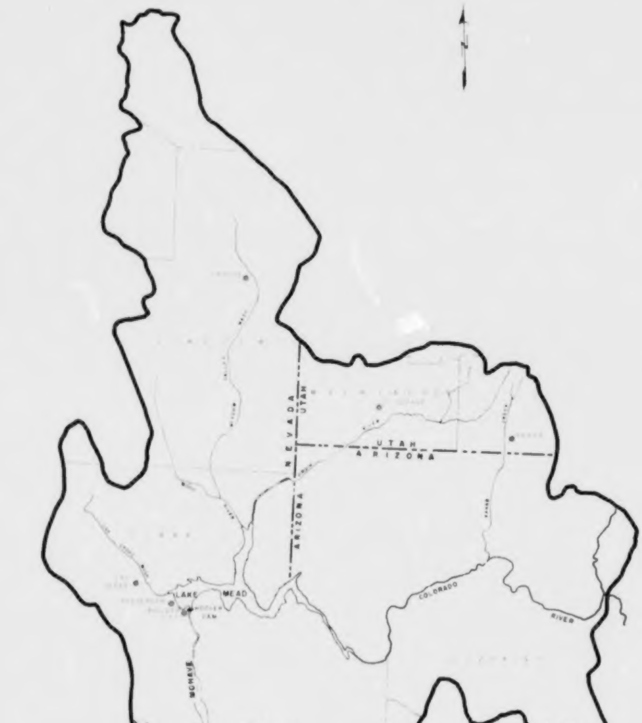
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DAVIS DAM
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SCALE IN MILES

COLORADO RIVER BASIN
WATER QUALITY CONTROL PROJECT

LOWER MAIN-STEM SUB-BASIN

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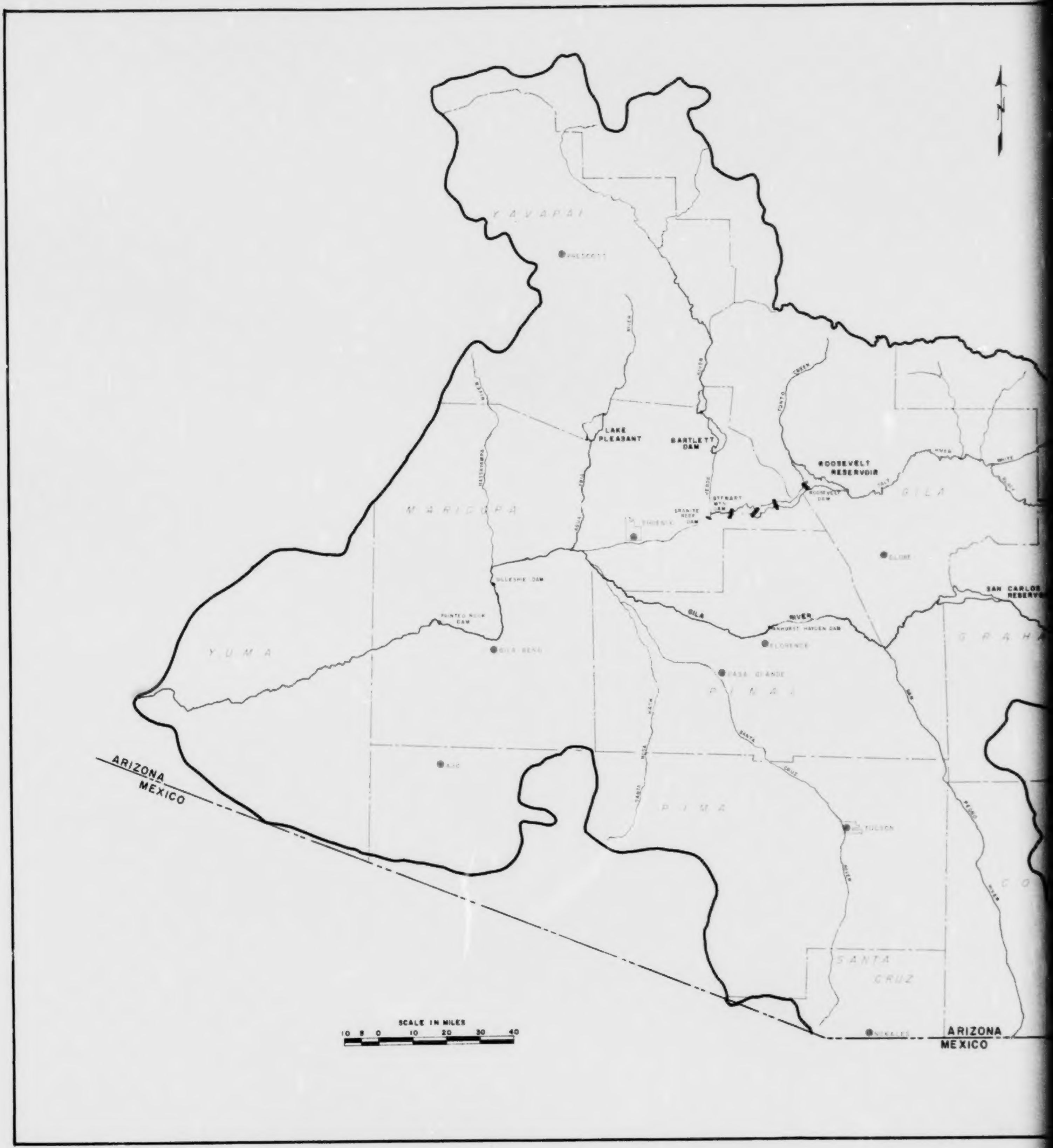
PUBLIC HEALTH SERVICE
REGION VIII DENVER, COLORADO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TONTO CREEK
LAKE PLEASANT
BARTLETT DAM
HASSAYAMPA
AGUA FRIA
ROOSEVELT RESERVOIR
ROOSEVELT DAM
STEWART MTN DAM
GRANITE REEF DAM
SALT
RIVER
WHITE
BLACK
GILA
MARICOPA
PHOENIX
GLOBE
GILLESPIE DAM
PAINTED ROCK DAM
GILA BEND
GILA
RIVER
ASHURST HAYDEN DAM
SAN CARLOS RESERVOIR
FLORENCE
CASA GRANDE
GRAHA
YUMA
PINAL
SAN
SANTA
CRUZ
SANTA ROSA WASH
AJO
PIMA
TUCSON
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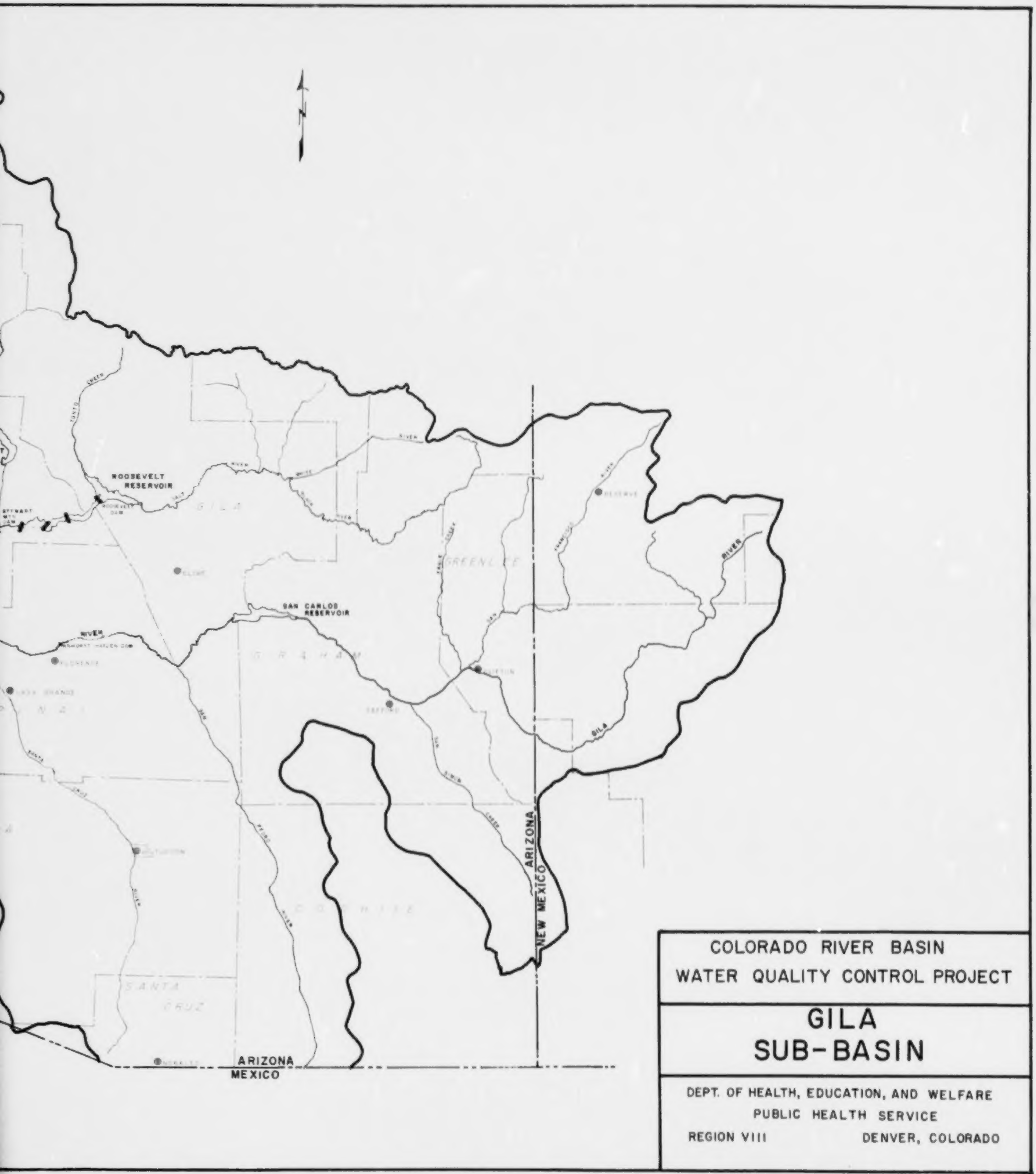
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STEWART MTN DAM
TONTO CREEK
SALT RIVER
WHITE RIVER
BLACK RIVER
GILA
GREENLEE
RESERVE
SAN FRANCISCO RIVER
RIVER
SAN CARLOS RESERVOIR
RIVER
COOLIDGE DAM
GLOBE
FLORENCE
CASA GRANDE
GRAHAM
SAFFORD
DUNCAN
GILA
SAN SIMON CREEK
SAN PEDRO RIVER
SANTA CRUZ RIVER
TUCSON
COCHISE
SANTA CRUZ
NOGALES
ARIZONA
NEW MEXICO
ARIZONA
MEXICO

COLORADO RIVER BASIN
WATER QUALITY CONTROL PROJECT

GILA
SUB-BASIN

DEPT. OF HEALTH, EDUCATION, AND WELFARE
PUBLIC HEALTH SERVICE
REGION VIII DENVER, COLORADO

Status of Salinity Damage Assessment.--Penalty costs in agricultural, industrial and domestic water supply have been estimated for the Lower Main Stem Subbasin and the southern California water service area. These costs are referred to the pristine and the present base levels of water quality, and therefore represent the direct additional expense to water users of all past changes in water quality, as well as anticipated future changes up to year 2010.

Similarly, penalty costs have been calculated for the areas in the Gila Basin which may be served by the Central Arizona Project. These comprise about 1,200,000 acres of agricultural land, as well as 140,000 acres in urban development in Maricopa County (Phoenix) and 45,000 acres in Santa Cruz County (Tucson). The base level of water quality in the CAP area is that projected for the year 1975, the date when the Central Arizona Project is assumed to begin operation. Estimates of salinity damages reflect water quality supposed to prevail in the year 2010 in the lower Colorado at the point of diversion for the Project near Parker Dam.

In the Upper Basin, assessments of potential salinity damages have been completed for the two areas deemed most likely to be affected, the Duchesne River Basin in Utah and the valley of the upper San Juan River in New Mexico. In those areas incidentally damages have been estimated to be either small or negligible.

An outline for the complete report has been prepared, and at the date of this writing, March 28, 1966, a draft of the introductory and central Chapters II-V is nearing completion. The principal remaining tasks are to recalculate salinity damages, at the water quality levels associated with the Economic Contractor's projections of future economic activity; collate and summarize the findings, prepare user cost curves, write the conclusions of the study and to review, edit and reproduce the manuscript.

The user cost curves referred to will relate changes in mineral quality to users' direct costs at key points in the lower river system. These will make it possible to evaluate the direct benefits of water quality improvement. They may be employed, for example, to estimate the benefits of suppression on diversion of the flow of a saline spring or of a program for phreatophyte control; or they may be used in calculating the water quality benefits component of a project for large scale importation of water, as from the Columbia River system.

Salinity Control

Work of the former Salinity Control Section was suspended October 15, 1965 in order to permit concentration of the engineering staff in the assessment of salinity damages, as well as to expedite the merging of engineering and economic efforts to evaluate the impact of water quality on the general regional economy. It is expected to resume study of salinity control measures upon completion of the major tasks in salinity damage assessment, scheduled for the latter part of this fiscal year.

Leading accomplishments in salinity control studies during the period of activity in 1965 included the following:

(1) Compilation of an inventory of more than 800 municipal and industrial waste water discharges throughout the Colorado River Basin.

(2) Preparation of a report in draft entitled "Preliminary Salinity Pollution Evaluation and Control Study (for) Colorado River Basin Above

Hoover Dam." The report identifies and evaluates the present origins of saline pollution, assesses future trends, and propounds several technically feasible methods to control or diminish saline pollution. Appendix A reviews in detail recent developments, methods, and costs of three possible systems of control, namely the reduction of evaporation from reservoir surfaces with monomolecular films; eradication of phreatophytes; and desalination processes.

Drafts of four additional appendixes for the above report were completed also, comprising proposed methods of salinity control in the Paradox and Sinbad Valleys of western Colorado, Blue Springs on the Little Colorado River in Arizona, the Virgin River area in Utah, Arizona and Nevada, and Las Vegas Wash in southern Nevada. A variety of control methods is considered, including the interception, storage and evaporation of saline flows, the pumping of saline waters from one subbasin to another in order to dilute them, and the desalination of brackish waste waters for reuse.

(3) An office study was made in September 1965 of the effect on water quality by complete drainage of a hypothetical 10,000 acre tract of irrigated land, with pumped recirculation of its irrigation return flows. This study envisaged maintaining a tolerable concentration in the recirculated water by blowdown and makeup, in the manner of an industrial system for recycling cooling water. The results of the study are considered promising enough to warrant its application to a real irrigated area, perhaps in the Grand Junction region in western Colorado, and this field study is scheduled to begin in late spring or summer of this year.

(4) Just before discontinuance of the work of the old salinity control

section, a beginning was made in the study of the quality benefits which would accrue from large-scale importation of water into Colorado River Basin, as from the Columbia, Snake, Yellowstone, or Trinity Rivers. Importation is now regarded generally as the eventual solution to shortages of water supply in this Basin, and the water quality benefits of such projects will have to be evaluated as an element in determining their economic feasibility. This means of water quality improvement of course does not detract in any way from the efforts required to abate pollution by treating or eliminating detrimental discharges of waste water.

Economic Studies

General.--The contract economic study was conducted by the University of New Mexico in collaboration with the University of Colorado until November 30, 1965, at which time the latter university became solely responsible for the nonagricultural sectors of the study. A separate agreement was negotiated on July 1, 1965, with the Economic Research Service, U. S. Department of Agriculture, for all components of the study relating to agriculture and forestry.

The Project economist was assigned responsibility for liaison between the Project and the economic contractors during FY 1966 to maintain closer communications and make sure that everyone was using the same resource base for projections to 1980 and 2010.

The demographic and input-output projections were revised to include the oil shale industry in the Upper Main Stem Subbasin and many large mine-mouth power plants in the Green, San Juan, and Lower Main Stem Subbasins. Additional revisions will be necessary if the proposed pulp and paper mills are included in the Green and Upper Main Stem Subbasins. These proposed industries require relatively large quantities of water and must be included to determine whether water quantity and quality are constraints in 1980 and 2010.

In July 1965, the Bureau of the Budget approved the economic questionnaire on capital expenditures. This questionnaire was especially important because it shows whether or not capital is a constraint on certain types of economic activity and it also supplements the data on interindustry transactions. Graduate students interviewed nonagricultural firms and completed the capital expenditures survey in November 1965.

The Project economists developed methodology for determining water requirements (net disappearance) for agricultural sectors in the Lower Main Stem Subbasin for 1960, 1980, and 2010 based on diversions, less system and farm conveyance losses, field losses and consumptive-use (evaporation and evapotranspiration).

The 1960 input-output tables were completed in October 1965 for the six subbasins and integrated through imports and exports for internal consistency. The two sets of projections, those of final demand and of technical coefficients for 1980 and 2010 were completed in November 1965 for the Lower Main Stem Subbasin. The projections were sent to the Economic Research Service for review and suggested changes. The two agencies then adjusted differences until both were in agreement. Projections of technical coefficients and final demand for the remaining five subbasins were completed in February 1966 and adjustments have been made for all the subbasins, with the exception of the Gila.

At a joint meeting of Project and economic contractor personnel in February 1966, methodology was developed for merging the economic and engineering data. A "trial run" of the Lower Main Stem Subbasin was made to test the methodology for merging the economic and engineering data. The "trial run" demonstrated that the methodology was satisfactory. A detailed description of the methodology is incorporated in a subsequent section.

In conjunction with the long-range projections, a series of industrial location studies have been completed by the economic contractor. The purpose of these studies is to anticipate the kinds of economic activity which might be represented in 1980 and 2010, but which were not present in 1960. Changes in water quality due to the above activities will be developed and inserted into the projected input-output tables through adjustment in final demand and water-use coefficients. The Green, Upper Main Stem, San Juan, and Little Colorado Subbasins will be studied simultaneously rather than sequentially and are expected to be completed by the end of FY 1966.

Value of irrigation water per acre-foot delivered at the farm headgate has been determined for the Coachella Project in Riverside County, California. The Imperial Project was also evaluated, but revision on a few of the major crops will be necessary before completion. Production and cost data have been assembled for the Palo Verde Irrigation District, Colorado Indian Reservation Irrigation District, Yuma and Gila Divisions of the Yuma-Gila Project, Salt River Irrigation District and the Duchesne Unit - Central Utah Project. The value of irrigation water for the Yuma-Gila Divisions will be determined by the end of this fiscal year. The methodology for determining the value of irrigation water is explained in detail in the following section.

Value of Irrigation Water.--The value of irrigation water per acre-foot is necessary for the appraisal of direct damages due to degradation of quality (salinity) over time. Direct damages include the following: (1) Cost of additional water required for leaching, (2) additional drainage and O&M cost, (3) additional labor cost, and (4) additional fertilizer cost.

The crux of the problem is how to determine the value of water for agriculture at different locations and under conditions peculiar to these locations. In an economic sense, the right to beneficial use of water is a vested right with monetary value, usually established by demonstrated beneficial use over a given period of time. In irrigation, demonstrated beneficial use (consumptive use) is evidenced by production of plants that have value to man.

Some of the methods that are in use for determining value of irrigation water include:

(1) Gross Value of Irrigated Crops Produced. This method is commonly referred to as the impact of water on a given area. Since water is used in combination with land, capital, equipment, labor, etc., this is not the true economic value of water.

(2) Direct and Indirect Benefits Resulting From Use of Irrigation Water. These imputed values are developed primarily by construction agencies, e.g., Corps of Engineers, Bureau of Reclamation and Soil Conservation Service. Each agency has a different method for calculating benefits, thus a uniform value cannot be derived.

(3) Market Price for Irrigation Water. This gives an economic value for water where a well organized market for irrigation water exists, as in the Delta area of Utah and the water is not appurtenant to the land. However, no such areas were found in the Colorado River Basin.

(4) Cost of Developing Irrigation Water Supplies. It is practically impossible to obtain cost of developing irrigation water supplies from individual farms, mutual irrigation companies, and irrigation districts because they do not keep accurate records and most of the projects were developed many years ago. Some of the irrigation districts have contracted with Federal and state agencies for new and supplemental irrigation water supplies. Where this has been done, the costs are quite accurate but usually the water is sold to the farmers at a subsidized price. To obtain the true cost of developing storage, diversion, and distribution cost, the entire costs must be updated to the present by use of Irrigation and Hydro Cost Indexes, U. S. Bureau of Reclamation, Denver, Colorado, 1949-51 = 1.0.

The cost of developing irrigation water on Bureau of Reclamation Projects, updated to January 1965, were calculated by the Project economists as follows: (1) Coachella Division, All-American Canal System, California, $13.98/a.f.; (2) Wellton-Mohawk Division, Gila Project, Arizona, $9.94/a.f.; (3) Valley Division, Yuma Project, Arizona, $9.89/a.f.; and (4) South Gila Valley Unit, Yuma Mesa Division, Gila Project, Arizona, $6.91/a.f. The composite cost of developing water on the last three projects was used for the "trial run" on the Lower Main Stem.

On-farm costs of water development were not included in the totals because they would be impossible to procure without considerable field investigation. In addition, cost of the by-pass canal to Mexico (about $5,000,000) was not charged against the Wellton-Mohawk Division, or any other project studied in the Yuma area.

The following procedure was used for calculating the above water costs for irrigation (present values):

(1) Use Bureau of Reclamation total cost of project for year of construction contract and multiply by difference in composite index (Irrigation and Hydro Cost Indexes - USBR, Denver, Colorado, 1949-51 = 1.0) to obtain present cost.

(2) Divide present cost (total) by total acre-feet delivered to the farms to get capital cost per acre-foot of water.

(3) Multiply capital cost by 3 1/8 percent for 70-year repayment period (.03535) to obtain annual amortized cost for construction per acre-foot of water developed.

(4) Use Bureau of Reclamation estimated annual OM&R cost per acre-foot for year of construction and multiply by composite index to acquire present annual cost.

(5) Add annual construction and OM&R together to get present annual cost of irrigation water per acre-foot at the farm headgate. Total costs of developing irrigation water is practically impossible to attain and cost of water may not be closely related to value of water. Off-farm cost of developing irrigation water by specific projects had its greatest usefulness when compared with the subsidized price farmers pay for water and the residual value of water.

As previously mentioned, no "rental market" or "market price" for irrigation water exists in the Basin, therefore the residual value (crop repayment capacity) of water is the next best measure of economic value, since residual value compares favorably with market prices where they occur. The residual (imputed) value represents what the farmer can pay for water without impinging on the going rate of return to other inputs (land, labor, capital, management, overhead, etc.) used in crop production. The following methodology for deriving residual value of irrigation water applies to the Coachella Project, California.

In calculating the imputed value of water, it is assumed that farmers seek the maximum profit and thereby adjust available resources to as near optimum level as possible. It is further assumed that sufficient homogeneity in climate, soils, cropping systems, management, and so on exist within each area to make aggregation for each major crop reasonably valid.

An investigation of the published sources for crop acreages, yields, and value prompted use of the County Agricultural Commissioner's reports where these were available. This was further confirmed by consultation with local, state, and government officials of the local area and on-site investigation. In addition, these data were compared with crop reports of the Bureau of Reclamation. These data were tabulated for the years 1960 through 1964 which provided five year averages for all major crops. Actual results for the five year average are shown in Table 1.

Prices for all major crops were computed as five year averages from the above sources. They represent prices received by farmers in the area for the years 1960 through 1964, controlled largely by supply and demand conditions. Specific problems or questionable data were resolved through direct consultation with farm advisors and other officials in the local area.

Certain crops, including alfalfa and asparagus, but particularly citrus crops, dates and grapes, require a large investment per acre for

Table 1

CROP BUDGET ANALYSES AND RESIDUAL VALUE OF WATER - COACHELLA VALLEY IRRIGATION DISTRICT, CALIFORNIA, 1960-64

	Acreage1/	Price Per Unit of Production1/2/	Yield Per Acre1/	Gross Value Per Acre1/2/	Cost of Production3/4/	Residual Value	Water A.F./Acre5/	Res. Value Water/A.F.	Total A.F. Water Applied	Total Residual Value Water
Barley	1,524	$ 1.20 / 50# Bushels	55.0	$ 66.00	$ 54.00	$ 12.00	3.0	$ 4.00	4,572	$ 18,288
Alfalfa	4,036	22.00 / Ton	8.6	189.20	146.20	43.00	8.0	5.38	32,288	173,548
Silage	594	7.20 / Ton	29.0	208.80	159.48	49.32	4.0	12.33	2,376	29,296
Cotton6/	5,857	173.00 / 500# Bales	2.5	432.50	320.08	112.42	7.0	16.06	40,999	658,444
Sugar Beets	1,316	14.65 / Ton	11.0	161.15	184.52	-23.37	5.0	-4.67	6,575	-30,755
Asparagus	1,850	7.15 / 30# Crates	63.0	450.45	410.45	40.00	5.0	8.00	9,250	74,000
Green Beans	231	6.05 / 30# Crates	96.0	580.80	663.51	-82.71	5.0	-16.54	1,155	-19,106
Carrots	3,192	2.20 / 48# Crates	447.0	983.40	874.68	108.72	4.0	27.18	12,768	347,034
Sweet Corn	4,875	2.55 / 50# Crates	150.0	382.50	342.68	39.82	5.0	7.96	24,375	194,123
Cantaloupes	453	3.20 / 48# Crates	100.0	320.00	398.80	-78.80	4.0	-19.70	1,812	-35,696
Onions (Dry)	138	1.55 / 50# Bags	570.0	883.50	826.18	57.32	4.0	14.33	552	7,910
Peppers	559	5.60 / 40# Crates	261.0	1,461.60	982.05	479.55	11.0	43.60	6,149	268,068
Squash	474	2.25 / 22# Flats	330.0	742.50	695.97	46.53	4.5	10.34	2,133	22,055
Radishes	427	1.70 / 25# Crates	415.0	707.50	710.40	-2.90	2.0	-1.45	854	-1,238
Egg Plant	232	1.98 / 20# Lugs	940.0	1,861.20	1,931.60	-70.40	8.0	-8.80	1,856	-16,333
Tomatoes	755	2.25 / 22# Lugs	1,192.0	2,682.00	2,439.61	242.39	15.0	16.16	11,325	183,004
Vegetables, Miscellaneous	382	2.90 /		1,244.40	1,104.07	140.33	5.2	26.98	1,986	53,606
Grapefruit	5,501	2.19 / 32# Cartons	285.0	624.00	551.23	72.77	7.5	9.70	41,258	400,308
Lemons	457	2.65 / 38# Cartons	345.0	914.25	814.86	99.39	8.0	12.42	3,656	45,421
Oranges, Val. & Naval	288	2.95 / 37.5# Cartons	235.0	693.25	526.69	166.56	7.5	22.21	2,160	47,969
Tangerines	1,500	3.00 / 45# Cartons	300.0	900.00	730.87	169.13	7.5	22.55	11,250	253,695
Dates	3,936	.0813 / Pounds	11,400.0	927.00	648.46	278.54	11.0	25.32	43,296	1,096,333
Table Grapes	11,159	3.70 / 24# Lugs	290.0	1,073.00	890.44	182.56	7.0	26.08	78,113	2,037,187
Citrus, Miscellaneous	304	3.40 /		648.43	569.39	79.04	7.0	11.29	2,128	24,028
TOTALS	50,040								342,886	$5,831,189
Wt. Averages Per Acre							6.85	$17.00		

1/ Source: Agricultural Commissioner's Crop Reports, Riverside County, Coachella Valley Water District, California.
2/ Prices represent those received by the farmer.
3/ Source: Cost of Production Records, Agricultural Extension Service, U. of Calif., Riverside County, California.
4/ Does not include cost of water.
5/ Source: Agricultural Extension Service, U.S.D.A., Riverside County, California.
6/ Includes cotton seed and lint.

establishing the stand or grove. These costs include various combinations of labor, equipment, materials, seeds, and plants. They vary considerably from area-to-area but it was considered reasonable to aggregate these costs for each of the above crops within areas. The costs were accumulated through the development period of the crop in question, generally to the point where returns began to cover costs, and discounted as applicable. The annual development cost was then computed for the life of the stand or grove.

Pre-harvest production operations generally involve land preparation, cultural practices and materials. Costs for all factors of production were included, except cost of water. Fertilizer rates, use of chemicals, and other practices vary by crop and area; therefore, the data used consisted of project and county cost data, reflecting local conditions prepared by the County Agricultural Extension Service for the area. This was supplemented by and adjusted where appropriate with information obtained from local farmers and produce cooperatives.

Harvesting costs are fairly straightforward for each major crop and include the cost of getting the product stored or ready for immediate marketing. Certain crops such as citrus and truck crops entail marketing costs which include charges or costs for grading, packing, advertising, selling, and commissions. It was necessary to distinguish as to whether these costs were paid by the farmer directly or by the packing house and then charged to the farmer.

Overhead costs were computed at 10 percent of total annual preharvest, harvesting, and marketing costs for each major crop. They include interest, taxes, insurance, administration, maintenance, repair, and general expenses.

The charge for operator's management was derived by taking 10 percent of the gross value for each major crop. Management charges vary considerably depending on the functions, services performed, and the crop grown; however, with the advice and assistance of California farm management specialists and others in agricultural research, it was considered reasonable to assume 10 percent for all major crop gross sales. The figure also compares closely with published data for southern California counties prepared by State Department of Water Resources, State of California.

Total cost of production is subtracted from gross value to obtain residual value per acre (Table 1). The number of acre-feet at the farm headgate is then divided into residual value per acre to procure the residual value of water per acre-foot. The total acre-feet and the total residual value for each major crop is determined by multiplying acre-feet per acre by acreage and the residual value of water per acre-foot by acreage, respectively. The total acreage is divided into total acre-feet of water applied for all major crops to get the composite acre-feet per acre, then the acre-feet of water applied is divided into the total residual value of all major crops to attain a composite value of water per acre-foot.

The quantity of water is based on application requirements for each major crop and the annual and seasonal water supply was assumed adequate to meet those requirements. Present irrigation efficiencies were considered only in relation to the amount of water applied in each situation. Efficiency rates will, of course, affect application requirements from one area to another, but these were assumed uniform for the local area under study. Water requirements in acre-feet per acre for each major crop are shown in Table 1, Column 7. The residual value ranged from -$19.70 to +$43.60 per acre-foot of water at the farm headgate for the major crops on the Coachella Project, California, with a composite average of $17.00 per acre-foot.

Since an adequate water supply-level is available to meet annual and seasonal requirements, the value per acre-foot is expected to be higher than when yearly or seasonal shortages exist. These relationships with respect to seasonal variations or additions to total supplied and its impact on marginal values or rental price have been appraised in earlier studies.

The preceding method of analysis for deriving the value of irrigation water will be applied to selected areas on the Colorado River system. Major areas to be included are: (1) southern California - the Imperial Irrigation District, Palo Verde Irrigation District, and Yuma Indian Reservation Project; (2) Lower Main Stem Subbasin; (3) Colorado River Indian Reservation Irrigation District; (4) Yuma Division and Gila Division of the Yuma-Gila Project; (5) Gila Subbasin - Central Arizona Project; (6) Green Subbasin; and (7) Duchesne Unit - Central Utah Project.

Methodology for Merging Economic and Engineering Data.--The method of analysis uses the input-output model developed by the Project's economic contractors to measure the effects of changes in water quality upon economic activity. The effects of changes in economic activity on water quality are likewise measured. One important feature of the input-output analysis is that both the direct and indirect effects of water quality changes upon economic activity are measured. Direct effects[*/] of water quality changes are entered through final demand sectors of the model as input data. The input-output model converts this input data to changes in total gross output, thus accounting for indirect effects. Therefore, changes in total gross output from the model provide a basis for measuring the total effect of water quality changes (degradation or improvement). Once a mathematical description of the indirect effects of quality changes has been formulated from the Project study, it will be of great assistance for purposes of water quality management.

Normally, as economic activity (measured by total gross output, or TGO) increases, more water is used, more waste water is generated, and less dilution water has been left in the receiving water body. Thus, water quality changes as economic activity changes. As water quality deteriorates, more water is required to maintain salt balance in industrial use processes such as boilers or cooling towers. More leaching water is required to maintain a salt balance in agricultural uses. Applying more water entails higher water-use cost for purchase, handling, treatment, and disposal of greater amounts of water for industrial purposes, and for additional leaching water, fertilizer, labor, and drainage in irrigation agriculture. As production costs increase some firms may be forced out of production or forced to shift production factors. Thus, in the aggregate sense, price increases or reduced production levels can be expected. This leads to lower output levels based on demand-price relationships.

[*/] Please refer to the following pages for a definition of terms used in this section.

Glossary of Terms

CONTROL COSTS - Cost of achieving an improvement in water quality, through control of natural or man-made pollution sources, through dilution with imported water, through desalination, or any other method.

RELATIONSHIP BETWEEN QUALITY AND ECONOMIC ACTIVITY -

$$\begin{bmatrix}\text{Water}\\ \text{Quality}\\ \text{Change}\end{bmatrix} \xrightarrow[\text{Balance}]{\text{Mass}} \begin{bmatrix}\text{Change in}\\ \text{Water Use}\\ \text{(Quantity)}\end{bmatrix} \xrightarrow[\text{Costs}]{\text{User}} \begin{bmatrix}\text{Final Demand}\\ \text{Change}\\ \text{(Direct Output}\\ \text{Change)}\end{bmatrix} \xrightarrow[\substack{\text{Transactions}\\ \text{(I-O model)}}]{\text{Interindustry}} \begin{bmatrix}\text{Change in Total}\\ \text{Gross Output}\\ \text{(Economic Activity}\\ \text{Change)}\end{bmatrix}$$

SECTOR - This term is defined as a grouping of firms which produce similar goods and services. In the model, sectors are arrayed as row and column headings. Outputs of industry or sectors are entered along the rows, and the inputs to these industry sectors are entered in the columns. Thus, the model is essentially a double entry bookkeeping system of accounting for inputs and outputs of sectors. The "Processing Sector: refers to a grouping of those sectors engaged in output of intermediate goods and services. The "Final Demand Sector" refers to a grouping of those sectors primarily engaged in final consumption of goods and services.

TOTAL GROSS OUTPUT - This term refers to the total output of goods and services. It includes those goods and services delivered to meet requirements of the final demand sector. TGO also includes goods and services which are used in the production process referred to previously as intermediate production.

USE COSTS - All identifiable costs (direct and indirect) associated with using water at a given quality level, as compared to a base quality level. Measured by the difference in total gross output of the economy associated with the two respective quality levels.

USER-COSTS - Costs associated with the employment of water in an economic activity, such as the value of the water, handling, treatment, disposal, and associated costs.

WATER QUALITY - Total dissolved solids in mg/l.

A step-by-step examination of the procedure for determining changes in economic activity attributable to changes in water quality follows:

Data requirements include tables of direct and indirect coefficients (I-O coefficients) for 1960, 1980, and 2010; projected water coefficients (W_i) in gallons of water per dollar of output; unconstrained projections of final demand for goods and services in the economy; projected water supply; and water quality projections.

Step 1. The matrix of I-O coefficients is post multiplied by the final demand vector. This multiplication is illustrated below. The resulting product is that level of economic activity required to meet the projected final demand.

I-O coefficients	x	final demand	=	total gross output
$\begin{bmatrix} I - A_t \\ \end{bmatrix}^{-1}$	x	$\begin{bmatrix} F \\ D \end{bmatrix}$	=	$\begin{bmatrix} T \\ G \\ O \end{bmatrix}$
multiplier effect of interindustry transactions	x	demand for goods and services	=	total output of goods and services

Step 2. Evaluate the effect of resource limitations upon production of goods and services. The water supply required to sustain the level of economic activity from Step 1 is determined by multiplying each sector in the TGO column by the appropriate water-use coefficient, as indicated below:

Output	x	water use	=	water demand
TGO_i	x	w_i	=	W_i
		Total Water Demand	=	$\sum W_i$
total gross output in $ value	x	gallons of water required to produce each $ of output	=	total water used

Water supply
" demand
Econ. activity (TGO)
adjustments
resources
Water quality

Step 3. The total water required to sustain this level of output, determined in Step 2, is compared to the existing available water supply. If the water demand exceeds the water supply, then the forecast must be reduced until the demand does not exceed the supply.

This is done by reducing final demand to a level less than that originally forecast, then calculating a new TGO, and finally a new total water use, $\sum W_i$.

$$\begin{bmatrix} I - A_t \end{bmatrix}^{-1} \times \begin{bmatrix} F \\ D \end{bmatrix} = \begin{bmatrix} T \\ G \\ O \end{bmatrix}$$

$$TGO_i \times w_i = W_i$$

$$\text{Total Use} = \sum W_i$$

This step is repeated until the demand for water is approximately equal to the supply.

The TGO figure thus achieved represents a base level of economic activity which we would forecast upon the basis of demand for goods and services by a growing population, and constrained, if necessary, by a limited water supply.

Step 4. Determine the effect of this level of projected activity upon the quality of the water supply. Essentially, quality deterioration results from several of man's activities including: (a) Population contributions by way of municipal and industrial wastes; (b) Consumptive use of water which concentrates existing salt into a reduced water supply; (c) Salts leached from the soil by irrigation and by seepage from industrial and other sources; and

(d) by reductions in the amount of dilution water available to absorb increased salt loads, through diversions out of the subbasin. Using projected levels of population and economic activity, together with forecast trends in water supply, diversions and other physical factors, new water quality conditions are forecast. Data from this step are saved for later use.

Step 5. Adjust the water-use coefficients to account for increased water use resulting from quality degradation determined in step 4. New water use coefficients are again multiplied by projected TGO to determine projected water demand. Resulting demand is compared with supply. If necessary, water demand is decreased by reducing the final demand obtained from the previous step, and determining a new TGO.

Step 6. Account for the effects of quality degradation. Additional costs are incurred as a result of water quality degradation. For agriculture, costs result from the need to purchase more water in order to maintain a salt balance. Applying more water, however, leads to the need for added labor, fertilizer, and drainage. Expenses for these items are called salinity damages since they are incurred as a direct result of water quality deterioration. Similarly, damages are incurred in industry where added water is needed to maintain salt balance in cooling and boiler feed water uses. Added water, however, means added treatment costs, etc. Also, for the municipal sector, damages are incurred through wasted soap, water softening expenses, etc. These damages result from increases in hardness. However, they may be expressed in terms of increases in TDS since TDS and hardness are related. Resources (dollars) spent on damages which result from water quality degradation are not available for purchases of goods and services from local producers, resulting in loss of local production. Value would have been added by this production in the local area, however such value-added is lost. An adjustment needs to be made in the final demand vector to account for this loss in economic activity. It may be necessary to consider other factors as well. For example, where soil or drainage problems exist, it may not be physically possible to utilize the extra leaching water required to maintain a salt balance under worsening water quality due to poor permeability of the soil. Such a condition could be accounted for in making the adjustments for quality-imposed quantity constraints. However, if no such constraints were applicable, it will be necessary to adjust the final demand column independently to account for this problem.

Step 7. After necessary adjustments to final demand have been made, a new TGO column is computed. This figure represents economic output of the subbasin after restrictions imposed by water quality degradation have been taken into account. Thus, the economic projections have now been constrained for water quality effects. The difference between the adjusted figure and the base TGO figure from step 3 represents the total (direct and indirect) effect of water quality degradation.

The presentation which follows describes engineering and economic principles used in performing the steps previously outlined. Relationships between engineering and economic theory are explained, and the techniques for merging these theories are presented. Finally, the proposed use of the input-output model for studying economic aspects of salinity controls is presented.

The most direct approach to the problem of predicting the effect caused by water quality changes is through mass balance. The fundamental idea of mass balance states that the amount of a substance entering a system must equal the amount leaving the system plus the change in storage within the system. This idea applies to the salt as well as the water. However, as a rule, very little salt is removed in the actual water use process, i.e., in the agricultural transpiration or plant uptake, in boiler steam, etc. Therefore, water must be wasted as leaching, blowdown, etc., to carry salt away from the system. This salt may be only the amount contained in the intake water, or it may be salt which was added in the use process.

For each industrial group of water users, called a sector in the input-output model, the amount of consumptive water use per dollar of output has been determined. For most efficient water use, salt load must be held at a maximum within the system since at the maximum salt concentration, the least amount of water is required to carry away the necessary salt load. Salt tolerance for the various sectors has also been determined either by interview or by literature review.

The above data have been incorporated into general equations and graphs which show the added water use for various water quality levels. Calculations showing the magnitude of increases in user costs for two assumed levels of economic activity, anticipated in target years 1980 and 2010 have been completed. These calculations have been explained in a previous section under the title of "damage assessment." These data are incorporated in the model studies to assist in generating the predictions of economic activity, TGO, for various water quality levels.

The relationship between TGO and water quality is one fundamental aspect of the benefit-cost analysis for salinity control projects, since the direct and indirect effects (identified as all use costs) of water quality degradation are measured by changes in TGO.

The objective of salinity control is minimization of costs associated with saline pollution. All identifiable pollution related effects are being evaluated for various levels of water quality. The cost of attaining various levels of water quality are likewise being determined. The sum of these two effects represent all identifiable costs for the various quality levels. The only problem remaining is that of determining the quality level for which total identifiable costs are minimized. The above described procedure is depicted graphically in Figure 1.

The input-output model is the source of data for generating a use cost, y_u, curve. Salinity-control-project feasibility and cost studies, together with waste collection and disposal cost studies by the Project staff will provide data for developing the control cost, y_c, curve. Combined, as illustrated, these two sources of information identify the most desirable level of water quality control. Benefit-cost analysis associated with this particular control level can also be evaluated. A brief outline of the methodology and statement of the progress on this phase of the Project's goals are presented in the following paragraphs.

As explained previously, water quality and economic activity are not independent of each other. Therefore, the relationship shown in Figure 1 is valid only for a certain level of economic activity. It is thus necessary to establish several y_u curves, corresponding to various levels of economic

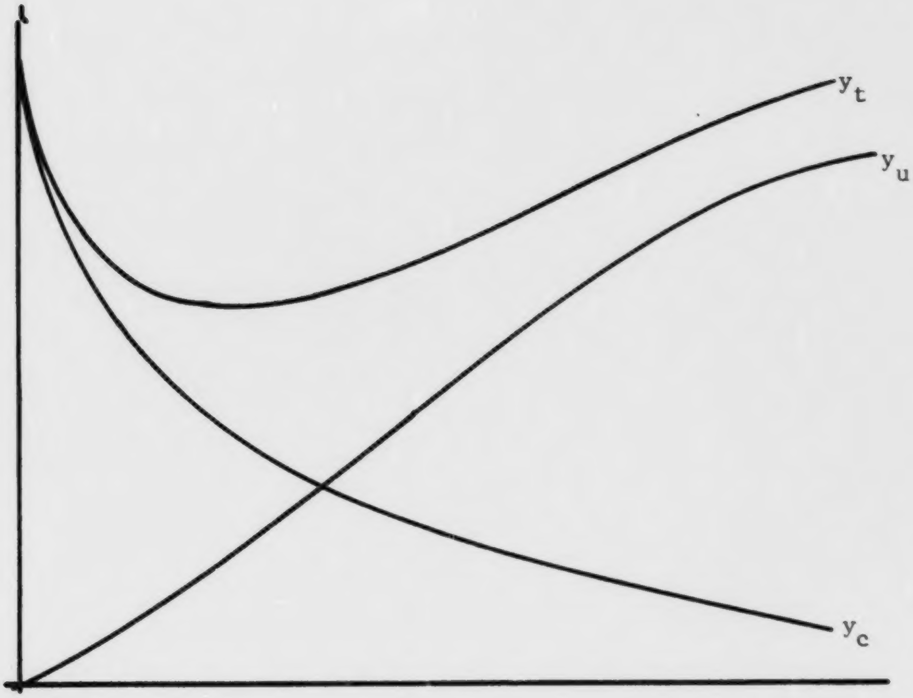


Fig. 1 Cost of Using Water as a Function of Water Quality

y_u = All identifiable use costs measured by changes in TGO.

y_c = Cost of quality control required to achieve various quality levels.

$y_t = y_u + y_c$

activity. Only two situations are being investigated initially, corresponding to levels of activity in 2 target years, 1980 and 2010. For each of these 2 target years, the Total Gross Output of the economy is determined based upon the expected demand for goods and services. Then, the effect of quality degradation associated with each forecast level of economic activities will be evaluated. Eventually, other alternative levels of economic activity and associated water quality levels may be considered in order to define more closely the "water quality-use-cost" relationship. By comparing the level of economic activity resulting from various quality conditions with the level of activity forecast before quality considerations were considered, the economic effect of the various water quality conditions can be examined.

It is also necessary to combine information from the family of use-cost (y_u curves) into a general relationship of the type shown in Figure 1. To do this, future use-costs are reduced to present value. The method outlined in the foregoing discussion is shown in Figure 2 and is explained as follows:

Step 1. Using the input-output model, calculate the total gross output associated with several levels of water quality. Plot the values of TGO vs. water quality as shown in Figures 2a and 2b.

Step 2. Calculate the changes in TGO, or use-cost, associated with various levels of water quality - referred to the base quality. To do this, read the base level TGO from the y axis intercept of Figure 2a, or 2b. Label these intercept values "A" and "B" respectively. Select an arbitrary water quality, x_1, and read the TGO associated with that quality from Figures 2a and 2b, labeling these readings t_1 and u_1 respectively. Plot change in TGO, $(A - t_1)$, and $(B - u_1)$, on Figures 2c and 2d respectively. Repeat this step

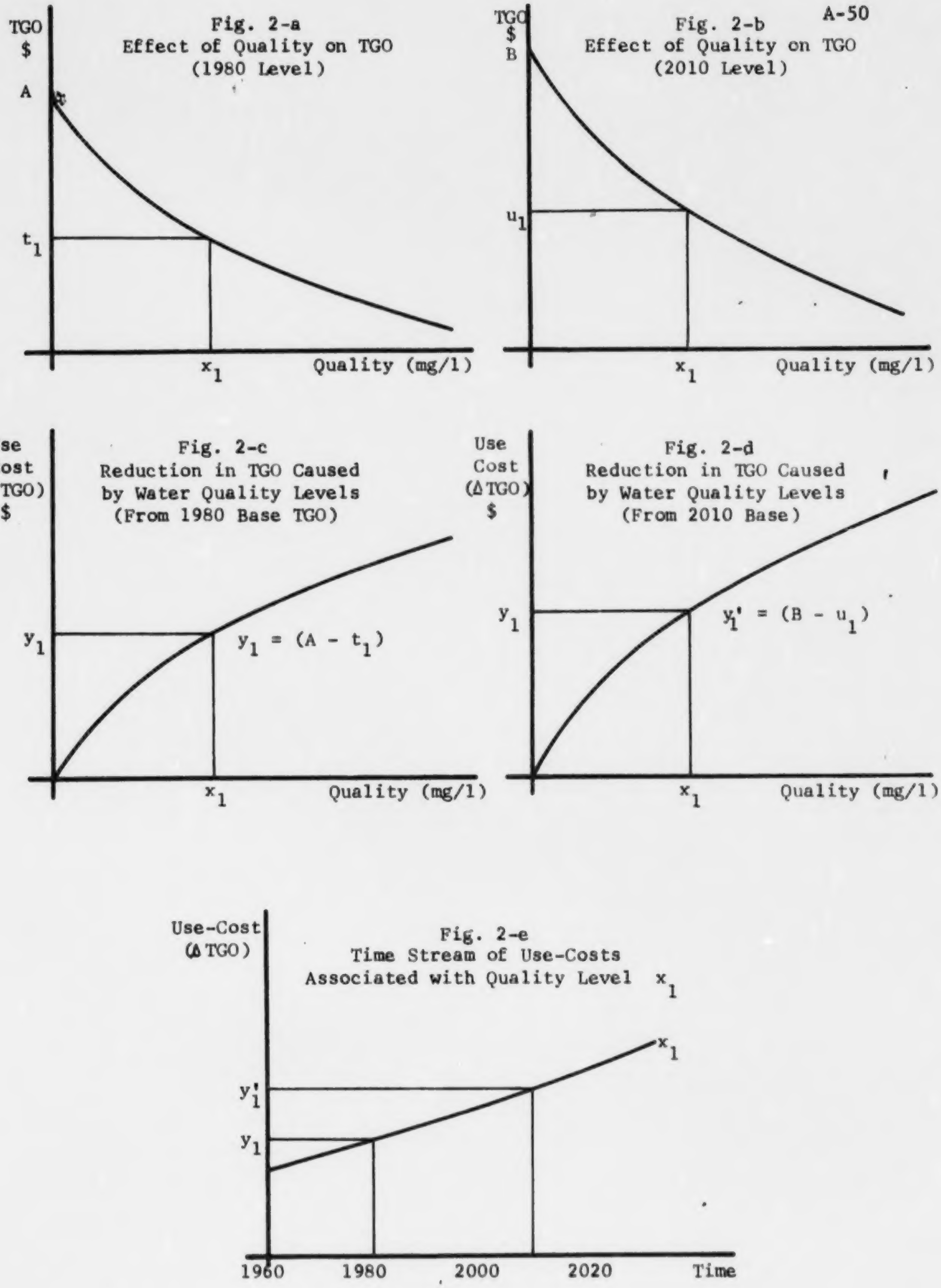


Fig. 2 Example of Methodology (continued)

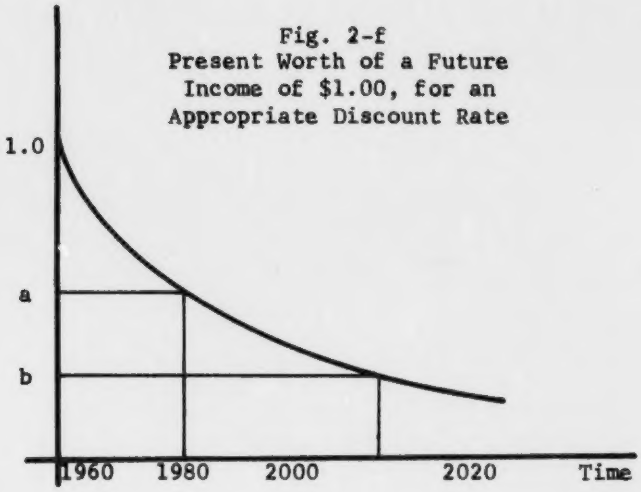


Fig. 2-f
Present Worth of a Future Income of $1.00, for an Appropriate Discount Rate

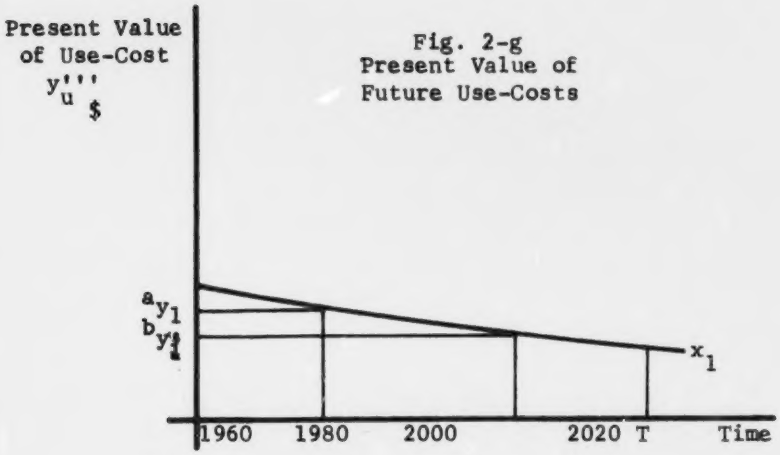


Fig. 2-g
Present Value of Future Use-Costs

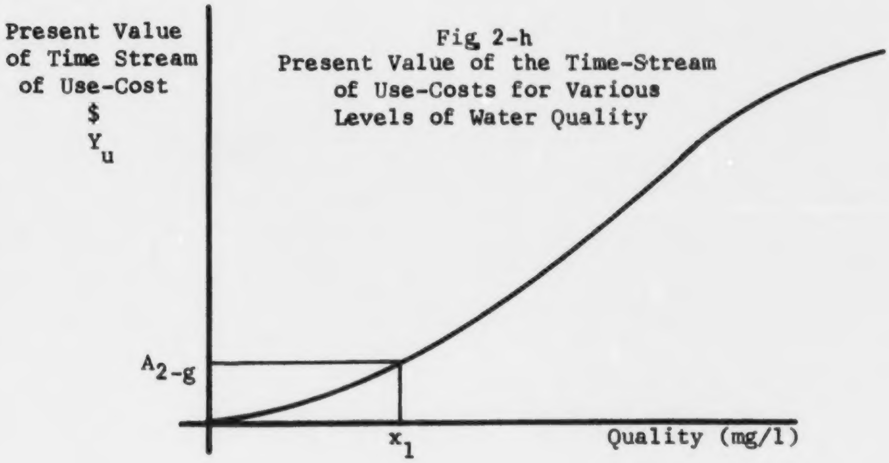


Fig. 2-h
Present Value of the Time-Stream of Use-Costs for Various Levels of Water Quality

Fig. 2 Example of Methodology

for several values of x_1 until the curve of Figures 2c and 2d are completed. (Or note that Figure 2c is Figure 2a revolved about y=A and translated to y=0).

Step 3. Determine the time stream of use-costs associated with each level of water quality. To do this, select an arbitrary value of water quality x_1, and read the use-cost, y, from Figure 2c. Plot this value of y on a graph of use-cost (ΔTGO) vs. time, at 1980. For the same value of x_1, read a use-cost y_1' from Figure 2d, and plot this value at 2010. Plot from source data, the ΔTGO associated with x_1 for the base year 1960. These three points define a curve, Figure 2e which represents the time stream of use-cost associated with an arbitrary quality level x_1. (As mentioned in the text, if three points are insufficient to define this curve, additional study may be required).

Step 4. Select an appropriate discount rate and plot the present worth of a one dollar future income - as shown on Figure 2f.

Step 5. Determine the present value of expected future use-costs. To do this, for each year read the expected use-cost from Figure 2e and the present worth coefficients from Figure 2f. For 1980 these are y_1 and "a" respectively. Multiply y_1 by "a" and plot (a y_1) at 1980 on Figure 2g. Similarly, plot(b y_1') at 2010 on Figure 2g; and so on for each year following 1960, until the curve of Figure 2g is completed.

Step 6. Determine the present value of the time stream of future use-costs. To do this, select a time horizon, T, where "T" is number of future years to be considered. Take the sum of the yearly "present-value-of-use-cost" figures calculated in step 5 from the base year through the "K" year. This sum represents the area under the curve of Figure 2g. Plot this area at x_1 on a curve of "The present value of the time stream of use-cost" vs. quality, Figure 2h. Repeat Steps 3 through 6 for several water quality levels until the curve of Figure 2h is completed.

The curve of Figure 2h gives the present worth of all use costs associated with a quality level x, and occurring in T future years, if quality were to be held constant at the level of x through these years. This use cost curve will lead to selection of one quality level which will minimize the future total water quality costs.

A similar concept is employed in establishing the curve of control costs, y_c. For each control possibility investigated, the magnitude of quality improvement and the project costs are estimated. These projects are then arranged in order of increasing values of "improvement in quality per dollar expended." The next step is to plot these projects on a scale of improvement-in-quality vs. dollars of control cost, as in Figure 3.

For a selected water quality, x_a, we must now return to the family of y_u data and select the water qualities associated with activity levels A, B, etc. These qualities, x_A, x_B, etc., are compared respectively with x_a. The costs of achieving TDS reductions $x_A - x_a$, $(x_B - x_a)$, etc. are read from Figure 3. Values read are plotted in a time series and the area under the curve represents the time stream of costs associated with maintaining quality level x_a. This time series, discounted to present value, is accumulated and plotted against the value of x_a. The accumulated value thus plotted represents the present cost of maintaining the quality level x_a throughout the time period T. An example of the procedure is sketched in Figure 4, and described as follows:

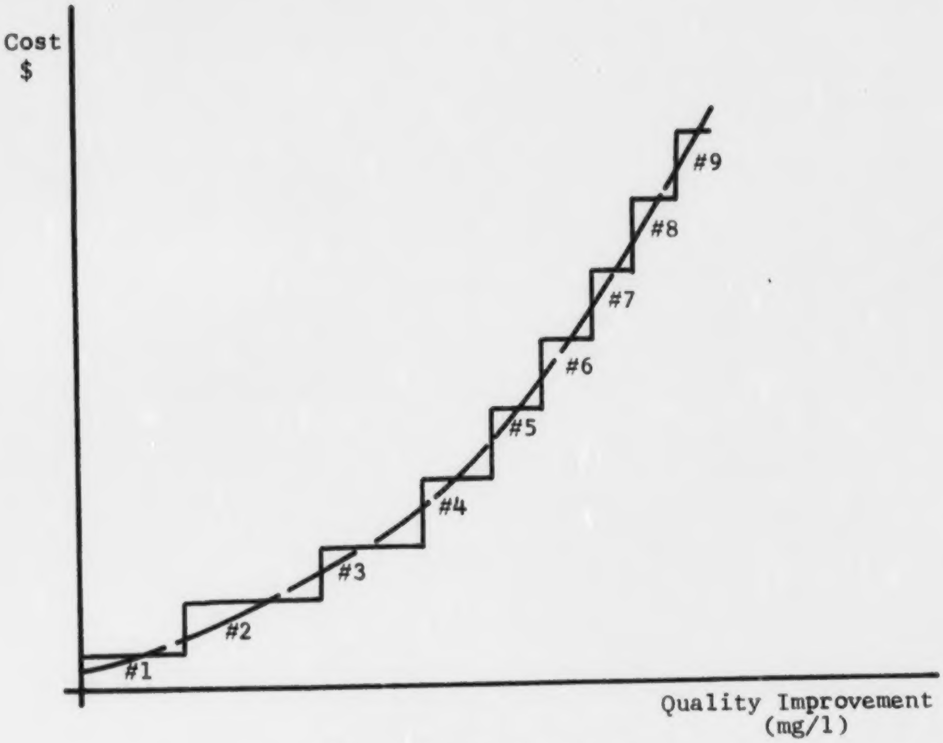


Fig. 3 Control Cost Curve

#1 - #9 are individual projects ranked in order of the improvement in water quality per dollar of control cost.

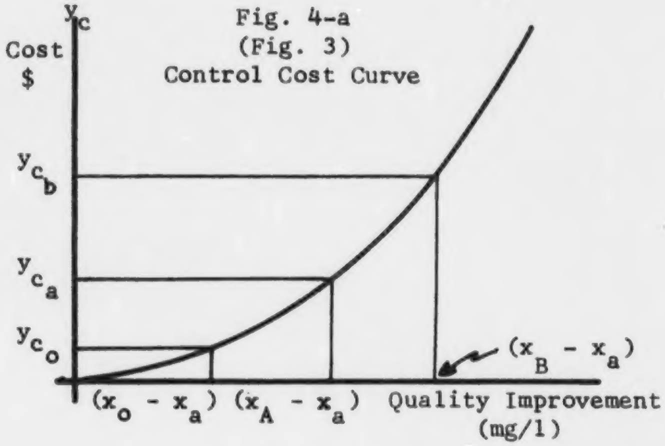


Fig. 4-a
(Fig. 3)
Control Cost Curve

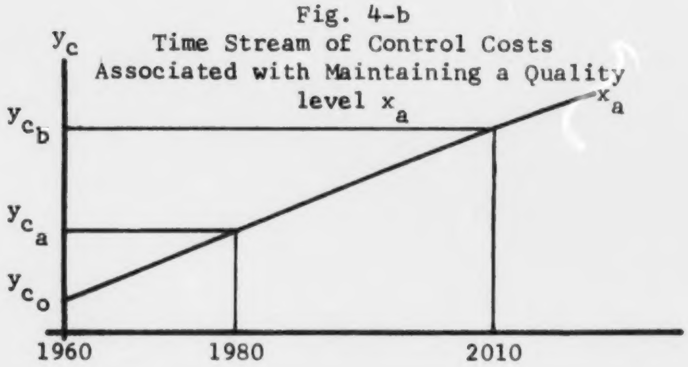


Fig. 4-b
Time Stream of Control Costs
Associated with Maintaining a Quality
level x_a

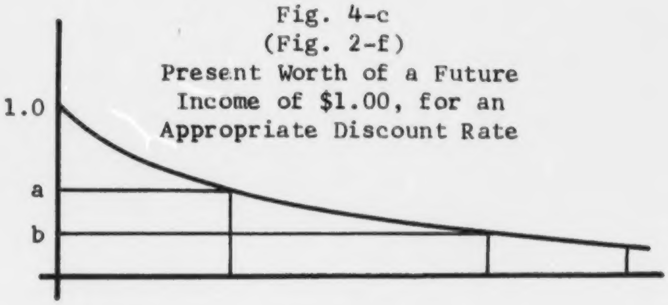


Fig. 4-c
(Fig. 2-f)
Present Worth of a Future
Income of \$1.00, for an
Appropriate Discount Rate

Fig. 4 Example of Methodology (continued)

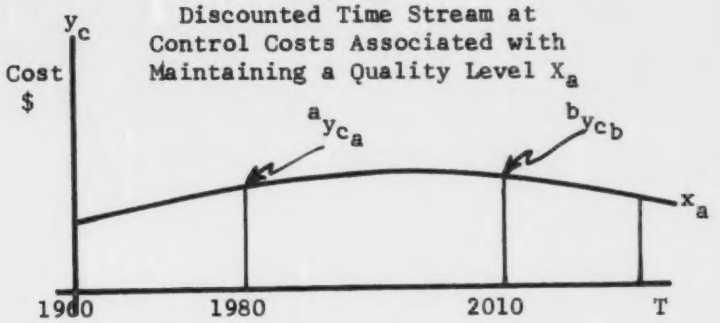


Fig. 4-d
Discounted Time Stream at
Control Costs Associated with
Maintaining a Quality Level X_a

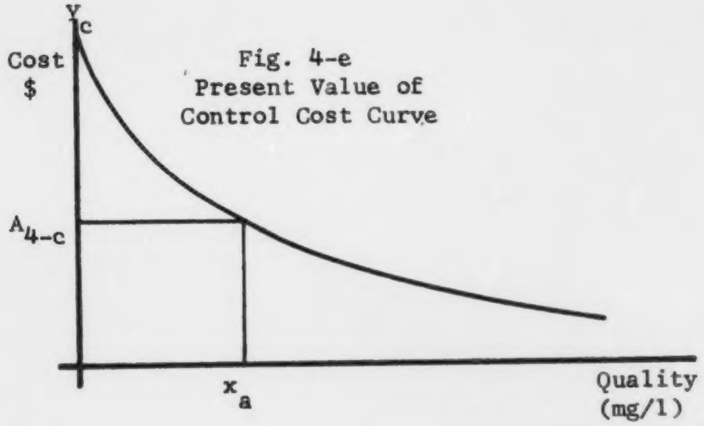


Fig. 4-e
Present Value of
Control Cost Curve

A_{4-c} = area under curve of Fig. 4-c.

Fig. 4 Example of Methodology

Step 1. Arrange control projects in order of increasing values of "improvement per dollar expended." Plot these projects on a graph of Quality Improvement per dollar of control cost - Figure 3.

Step 2. Draw a smooth curve through these projects. (This is merely done for ease of calculation. The step curve is used finally in determining the control level.) (Figure 4a)

Step 3. Select an arbitrary water quality x_a, and determine the difference between that quality and the water quality associated with activity levels A and B. The latter values were determined in the model run, since the first step in any run is to project TGO independently, and then adjust water quality to account for the increase in TGO. Essentially then, this step involves selecting the cheapest possible way to partially offset the effect of increased TGO, so that water quality may be held at x_a. Plot the cost of achieving a quality reduction $(x_A - x_a)$, read from Figure 4a, at 1980, on a graph of control cost vs. time. Plot the cost of achieving a quality reduction $(x_B - x_a)$ at 2010. Plot the cost of reducing the 1960 quality to level x_a at 1960. These three points define a curve of the time stream of control costs associated with a water quality level x_a, as shown on Figure 4b. (As noted previously, if three points are not sufficient to define this curve, additional study will be required.)

Step 4. Select an appropriate discount rate and determine the present worth of a one-dollar future income, Figure 4c.

Step 5. Determine the present value of expected future control costs (Figure 4d). (See Step 5 of use-cost example.)

Step 6. Determine the present value of the time stream of control cost. (See Step 6 of use-cost example.)

Step 7. Plot the present value of the time stream of control costs (area under curve of Figure 4d) at x_a as a graph of "time-stream-of-control-costs" va. Quality, Figure 4e. Repeat steps 3 through 6 until the curve of Figure 4e is completed.

Figure 4e represents the present value of the cost of maintaining a specified level of water quality, x_a, through T future years, considering increases in the applied pollution load.

Control costs and use-costs are next plotted on a common set of axis to form the general relationship depicted in Figure 5.

The Y_t curve may be determined graphically by adding selected values of Y_u and Y_c; or, equations may be established for the Y_u and Y_c curves, and Y_t determined analytically.

If the latter approach is used, the minimum cost solution is maintenance of that quality level for which $\frac{d\ Y_t}{d\ X} = 0$. Once this quality, $\hat{X}$, is known, the number of projects required immediately to achieve quality level $\hat{X}$ may be determined from Figure 3. It is possible to determine which projects will be desirable in the future and at what future date each should be completed, in addition to the relative benefit/cost ratios.

From an economic standpoint we would choose to install salinity control until the cost of achieving an increment of quality improvement was greater than the benefit derived from that increment of improvement. In this case however, benefits are the reductions in use-costs. Thus, the quality level, $\hat{X}$, for which the slope of the Y_t curve is zero, identifies the point at which control measures begin to cost more than they will return through reduced use-costs. Returning to the Figure 3, one can select the number of projects

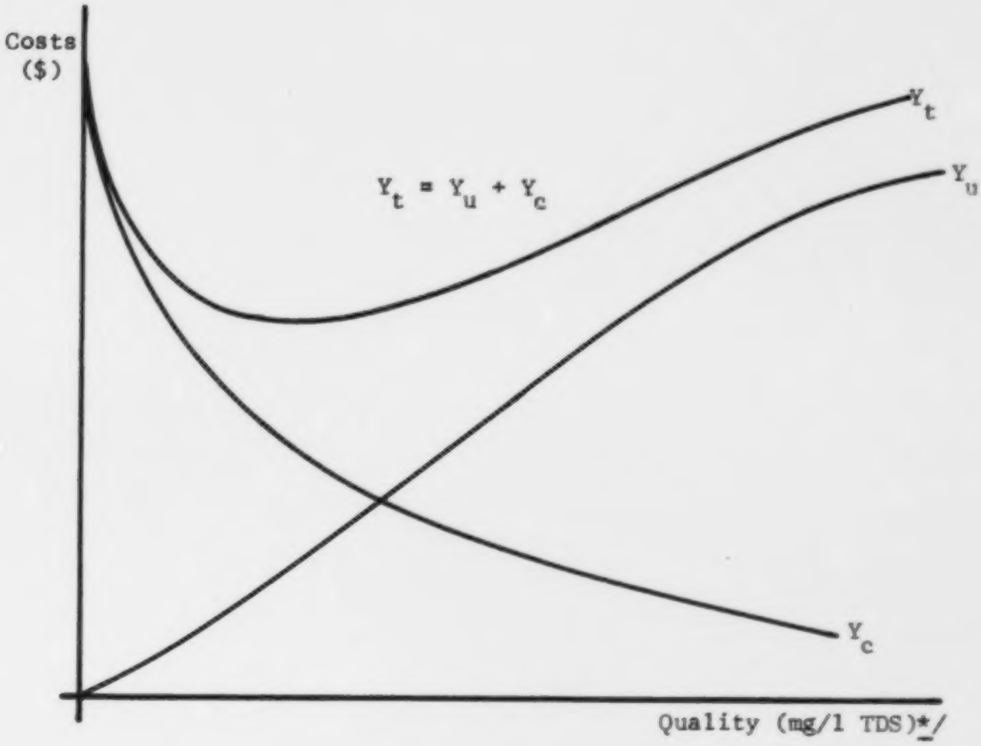


Fig. 5 Present Value of Time Stream of Cost Associated with Water Quality

*/ Figure 5 is not identical to Fig. 1, as it may appear. In general $Y_u = \sum_{i=1}^{T} C_i \ (y_u)_i$ where C_i is the present worth of a $1 income in the i^{th} year, and y_{u_i} is the use cost associated with the level of economic activity in the i^{th} year. A similar relationship exists between Y_c and y_c.

required to achieve the appropriate water quality level, $\hat{X}$. Since it is unlikely that the point chosen will coincide exactly with a given full scale project, the project spanning $\hat{X}$ will be recommended or deleated, as appropriate. One may select the benefits associated with installation of water quality controls by reading values from the Y_u curve, and from the Y_c curve of Figure 5. An example of the foregoing discussion is presented as follows:

(Figure 5 has been reproduced here for convenience in following this example).

Step 1. Determine the optimum water quality level ($\hat{X}$) by reading from the X axis below the zero slope on the Y_t curve of Figure 5.

Step 2. Obtain the control cost of maintaining this optimum level by entering Figure 5 at $X = \hat{X}$, and reading the cost from the Y axis opposite the control cost curve (Y_c). In this case the control cost is C'.

Step 3. Determine the benefits associated with maintaining the optimum water quality level as follows:

a. Obtain existing use-cost by entering Figure 5 at the existing water quality X_e, and reading from the Y axis opposite the Y_u curve. In this case (U_e).

b. Obtain use-cost for the optimum quality level by entering Figure 5 at $X = \hat{X}$, and reading from the Y axis opposite the Y_u curve. In this case (U').

c. Determine benefits which are the reduction in use-costs: Benefits, $B = (U_e - U')$.

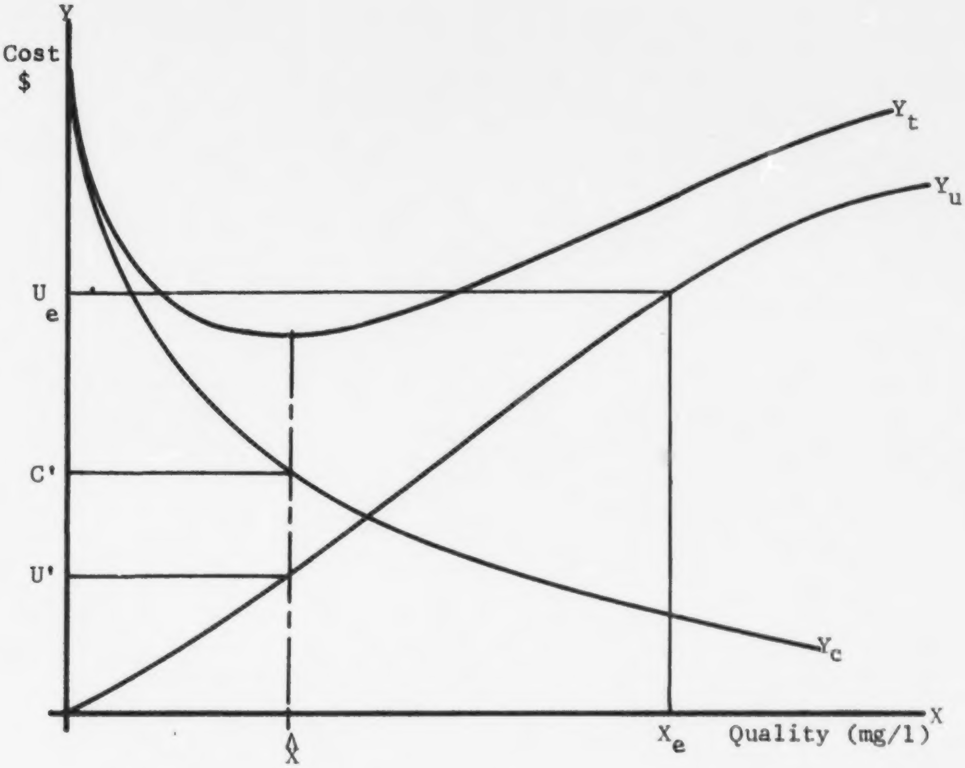


Fig. 5 Present Value of the Time Stream of Cost Associated with Water Quality

Step 4. Calculate the benefit/cost ratio: $B/C = \frac{U_e - U'}{C'}$

The benefit cost ratio from Step 4 is the one associated with maintaining an optimum quality level over the next "T" years. One or more individual water quality control projects may be required, to reach this optimum quality level. Other projects will be required in future years to maintain that level, because of increasing pollution loads from expanding economic activity. The benefit-cost relationship for each of these required projects may be examined independently, once the projects have been scheduled.

To determine the number of projects required, and to determine when they will be needed, one can use the curve of future water quality associated with the activity levels A and B, previously defined. These values have been plotted and explained as the curve labeled X_1 of Figure 6.

A graphical method of selecting those projects which are desirable, and of scheduling their construction is presented as follows:

(Figures 3 and 6 have been reproduced for convenience in following this example)

Step 1. Determine the number of projects required immediately to reduce presently existing quality to the optimum.

a. Determine quality reduction required by reading initial quality X_o from Figure 6, and comparing with optimum quality:

   $\text{Control} = C_o = (X_o - \hat{X})$

b. Determine the number of projects required to achieve a reduction C_o, by reading from Figure 3. (In the example depicted on the previous page, 1-1/2 projects are required, so either 1 or 2 projects must be installed.)

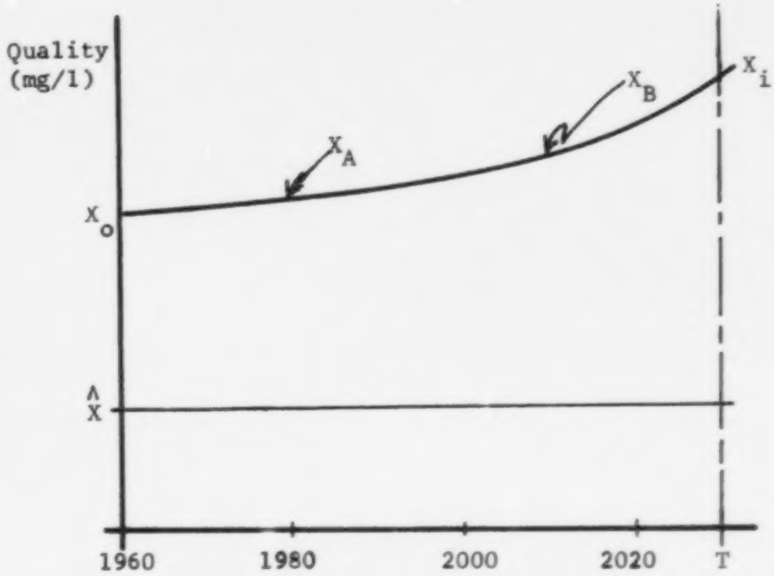


Fig. 6 Future Water Quality Associated with Respective Future Base TGO Levels

X_o = 1960, or base year water quality.
X_A = Water quality associated with the 1980 base TGO (from first round model adjustment).
X_B = Water quality associated with 2010 base TGO

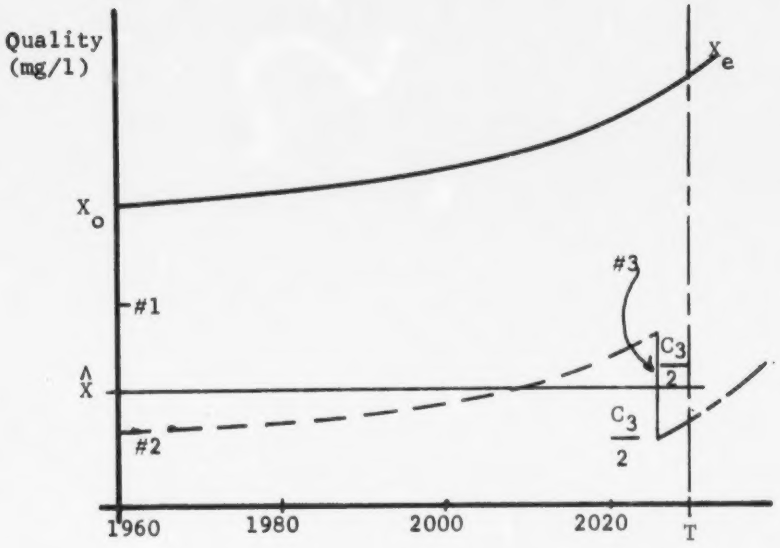

Quality
(mg/l)
X_e
X_o
#1
#3
$\frac{C_3}{2}$
$\hat{X}$
#2
$\frac{C_3}{2}$
1960
1980
2000
2020
T

Figure 6

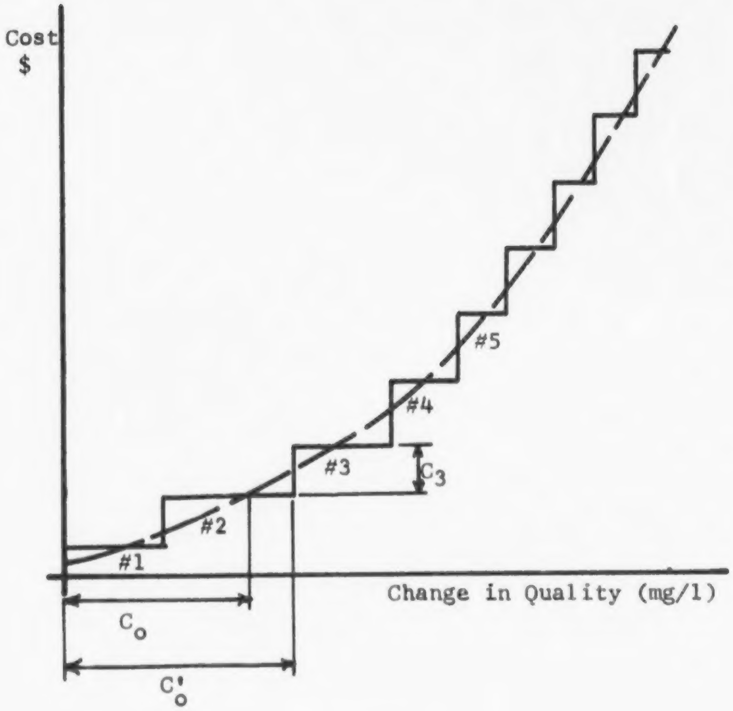

Cost
$
#1
#2
#3
C_3
#4
#5
Change in Quality (mg/l)
C_o
C'_o

Figure 3

Step 2. Determine the quality reduction actually achieved by installing the nearest whole number of projects (in the example depicted, 2 were chosen so the change is C_o').

Step 3. Move the curve of base quality levels (X_i) down by an amount C_o' to a new position (as shown on Figure 6 depicted on the opposite page by the dashed line-----).

Step 4. Read the quality reduction accomplished by project #3 from Figure 3, and label this value C_3.

Step 5. Move along the line $X = \hat{X}$ until the translated curve is above the line $X = \hat{X}$ by one half of C_{3_o}. Plot C_3 downward from the dashed line as shown.

Step 6. Translate the curve of X_i down to the base of the verticle line plotted in step 5, as shown by the line—— – ——.

Repeat steps 4, 5, and 6 for successive projects until the time horizon, T is reached. In the example, no more projects need be transferred to Figure 6.

Step 7. Determine the number of projects required, by noting how many were translated to Figure 6. In this example, 3 projects were transferred.

Step 8. Select the appropriate date for completion of each project by reading the date corresponding to its plotted position on Figure 6. In the example, projects 1 and 2 are required now, while project 3 will be needed much later.

After the scheduling of projects has been completed, it is possible, by using the appropriate curve of the type shown in Figure 1, to determine the benefit cost relationship for each individual project. When this final step has been completed, the studies will be finished.

Progress on the model run has been discussed previously. A trial run has been completed and the model is now being used to determine user costs (Y_u values) for various water quality conditions associated with 1980 and 2010 levels of economic activity. These target years, and the information from 1960 establish three sets of curves of the type Figure 2c and Figure 2d. Such curves in turn establish three points on the basic source curve Figure 2e. Three points may be insufficient to identify clearly the nature of Figure 2h, in which case additional information will have to be examined.

Studies of controls for several natural sources have been completed. Study of several pollution abatement possibilities are planned for the next few months.

In conclusion, the methods have been selected, the contractors input-output model has been successfully tested, and several engineering control studies have been completed, or are underway. The next year should see a blending of these components into a useful water quality management tool.

Municipal, Industrial, and Related Water Pollution Problems

With the Project's efforts focused primarily on the radiological and salinity pollutional aspects in the Colorado River Basin, little time has been devoted to other forms of water pollution until this fiscal year. Various pollution problems arising from municipal and industrial waste water discharges have been noted in the field by Project personnel and reported by state authorities during the course of the Project's work. However, because of the nature of the charge to the Project by the Conferees, an accurate and factual evaluation of these pollution problems and their impact on downstream water uses has not been accomplished to date.

During the fall of 1965, a program was initiated to examine all sources of municipal and industrial waste water discharges throughout the Colorado River Basin, excluding the Gila Subbasin. State health and fish and game personnel were contacted to collect information on municipal and industrial waste sources and existing pollution problems were noted within the various states in the Basin. This information, combined with the field reports and data collected by the Project, was assembled and presented at a Progress Meeting held December 13, 1965 in Grand Junction, Colorado.

The need for a more thorough and complete inventory of municipal and industrial waste discharges with supporting documentation of downstream pollutional effects evolved from this meeting. Chairman Murray Stein asked that the Project, in cooperation with concerned state agencies, develop a program to identify municipal and industrial water pollution problems and develop a pollution abatement program to resolve these problems, along with a time schedule for compliance. This proposal was concurred in by the six states represented at this meeting.

In January 1966 the Municipal and Industrial Unit was established within the Pollution Damage and Control Section to devote specific attention to municipal, industrial, and related water pollution problems. Activities and accomplishments pertaining to these pollution problems during FY 1966 are discussed below.

Municipal and Industrial Pollution

Inventory of Municipal and Industrial Waste Sources.--To fully evaluate the existing and potential municipal and industrial water pollution problems in the Basin, a complete and current inventory of waste sources is required. The existing inventory compiled in 1964-65, although extensive, still does not provide a complete listing of waste sources, especially industrial. In many cases data are lacking on volume and characteristics of the waste water discharges. The existing inventory does provide an excellent basis from which to make a complete and current waste source inventory.

In assembling the new inventory of M&I waste water sources and treatment facilities, appropriate state water pollution control agencies have been, or will be, contacted to obtain existing waste source data. Field visits to various sources are presently being made as necessary to determine waste water disposal practices.

A draft of the new municipal and industrial waste source inventory is expected to be complete by July 1, 1966.

Field Studies.--There is a definite lack of basic data to support action for municipal and industrial pollution control in the Colorado River Basin. It is known, however, that serious water pollution resulting from M&I waste water discharges does indeed exist in several of the streams in both the Upper and Lower Basins. Field personnel of the Project have observed what may be considered unsatisfactory waste effluents being discharged from both municipal and industrial sources to various streams and subsequent downstream water quality degradation. The Colorado State Department of Game, Fish, and Parks have ceased to stock fish in many streams in Colorado because toxic and other wastes discharged to these waters will not permit aquatic life to exist. The Utah Department of Fish and Game has also recognized several pollution problems in that state.

A staff member of the Field Station investigated a report that a farmer was dumping melons into the Colorado River near Yuma, Arizona. This was not substantiated; however, it was found that a melon packing operation in Yuma was grinding cull melons and discharging the resultant pulp to the river. The offending industry has made no change in the physical plant and apparently intends to repeat the practice during the coming melon season.

The Field Station staff conducted special sampling of the San Miguel River above and below the Union Carbide Nuclear Plant at Uravan, Colorado during the high flow period of last spring. This sampling was undertaken becuase of the decision by the company and the AEC to discharge material known as the "Plant No. 5 waste" (yellowcake) directly to the San Miguel during the period of spring runoff. This material is normally discharged into ponds which obstensibly seep in a direction away from the river. This discharge was found to cause a significant increase in TDS and to suppress pH by as much as 1.0 unit, at streamflows as high as 1,200 cfs.

On March 23, 1966, the Chief, Radiological Unit, during his annual sediment survey of the Basin, learned from officials at the Union Carbide Nuclear Plant at Uravan that plans were being made to begin discharging Plant No. 5 waste to the San Miguel River again this year. The waste discharge was to begin on April 1 and continue for about two months. The Project headquarters contacted both the Colorado Department of Game, Fish, and Parks and the Colorado State Department of Health to determine if Union Carbide Corporation had notified them of the discharge plans. It was found that neither of these state water pollution control agencies knew anything about this matter. The Colorado Department of Game, Fish, and Parks dispatched two fisheries biologists to the mill on March 25, 1966 to determine more precisely what the discharge plans were and to observe flow conditions in the river. The mill had already began to discharge the waste water. Plans are presently being developed to work jointly with the State of Colorado in monitoring, evaluating, and reporting the effects of this waste water discharge.

A sanitary survey was conducted in the vicinity of Delta, Colorado in November-December 1965 to ascertain the effect of a sugar beet refinery and two food processing plants on the Uncompahgre and Gunnison Rivers. Although significant BOD loads were being discharged, no serious depletion of dissolved oxygen was found to exist in the streams. This was probably due to suppression of bacterial activity by the supercooled water in the receiving stream.

The Field Station staff planned and conducted a preliminary sanitary survey during October 1965 on the Colorado River near Yuma, Arizona. A significant pickup in BOD and suppression of instream dissolved oxygen was observed. Additional survey work in the area now awaits the end of inflow from the Gila River. This inflow is due to abnormally high runoff in the Gila Subbasin and is the first such flow since 1937. Therefore, such a survey on the reach of the Colorado River below the mouth of the Gila River would not represent typical conditions and the results would be subject to some doubt.

With the Field Station and Laboratory presently preoccupied in completing salinity studies and analyses, the Project has limited capacity to conduct much needed conventional surveys. In February 1966 a proposal was submitted to the Robert A. Taft Sanitary Engineering Center requesting their technical assistance in making several water pollution surveys. A review of this proposal was made by SEC personnel and it was decided that the following studies will be made in the Lower Basin this fiscal year by SEC personnel with the support of the Project.

1. April 1966: Dr. Ingram, SEC, will conduct a general biological survey from Lake Mead to Yuma. This survey will establish the need for additional more extensive investigations.

2. May 1966: An extensive water quality and waste source study in Las Vegas Wash and Las Vegas Bay of Lake Mead will be made by Mr. F. W. Kittrell and his staff. In addition to the Las Vegas Wash survey, a bacteriological and nutrient investigation of Lake Moovalya below Parker Dam will be made during this period.

The May survey in Las Vegas Wash is of extreme importance in that there is a definite need to show the effects of pollutants entering Lake Mead on the water uses in that impoundment. This problem was discussed briefly in the introductory remarks. The Bureau of Reclamation and the Lake Mead National Park Service are highly concerned with waste water discharges to Lake Mead. The data collected from these surveys will be evaluated with appropriate recommendations made and included in the Project's final report.

Nutrient Pollution

With the increasing number of reservoirs being developed in the Basin and their extensive use for recreational activities, as well as for domestic water supplies, it is apparent that nutrient pollution may become an important problem. In view of this, the Project has undertaken a program to evaluate existing nutrient data for the surface waters of the Basin.

Consultations were held with Dr. W. M. Ingram, Robert A. Taft Sanitary Engineering Center, to discuss what steps the Project might take now to investigate the potential of eutrophication in the reservoirs of the Basin. Dr. Ingram suggested that we evaluate any nutrient problems that might exist now and examine locations for proposed recreational facilities on reservoirs giving consideration to wind and water density currents in the area. With good mixing conditions, nutrient build-up potentials are reduced.

During the course of the April field biological investigations by Dr. Ingram's staff and through contact with state officials, existing and potential nutrient pollution problems in the Basin will be identified and evaluated.

Recreational Pollution

There is intense development for recreation in the Colorado River Basin. With the trend toward more outdoor sport and water oriented recreation, several pollution problems have developed in the Basin.

At Lake Moovalya, below Parker Dam, 30 to 50 thousand recreationists crowd this sixteen-mile long narrow impoundment during weekends and holidays. Water pollution from overloaded resorts has been reported. There is a potential nutrient problem here also. The water quality problems in this area will be studied and evaluated during May as outlined above.

Rapidly developed and booming ski resorts, such as Breckenridge, Vail, and Aspen, have not planned adequately for waste water disposal. It has been reported that existing treatment plants at these resorts are being overloaded and creating water quality problems downstream.

The Municipal and Industrial Unit is gathering assorted information on these recreational pollution problems and will provide states assistance in solving existing and potential future recreation associated water pollution problems.

Information was requested and obtained from the Lake Mead National Park Service regarding their control of waste water discharges from boats operating on the reservoir. The states in the Basin will also be contacted to determine what, if any, regulations they have for controlling these waste sources. Additional contact with the Lake Mead National Park Service will be made during the April and May studies in that area to secure more specific information on the enforcement of waste water discharges from boats and the needs for further evaluation of this source of water pollution.

Oil Pollution

The potential sources of oil pollution in the Colorado River Basin are located in areas where oil is being pumped and where there is close proximity of oil transmission lines to streams and lakes. Extensive oil drilling and production operations exist in the Green and San Juan Subbasins. Oil transmission lines cross the Basin in several locations.

The Project continues to collect basic information relating pollution evolving from oil field operations. The Project Director, along with biologists of the Colorado Game, Fish, and Parks Department, accompanied officials of the Chevron Oil Company on an inspection of oil field operations and waste disposal practices in the Rangely Oil Field in northwest Colorado. Various potential pollution problems were observed such as brine evaporation ponds constructed in streambeds where they could easily be washed out during a heavy rainfall.

The Project will document all oil fields and their waste disposal practices in the inventory now being compiled.

Waste Water from Federal Installations

Although the Regional offices have the responsibility of evaluating waste water disposal practices at Federal installations, the Project continues to support this activity. It is the practice of the Project to notify the appropriate Regional offices of inadequate treatment facilities at Federal installations as they are revealed during various Project field activities. In several cases potential pollution problems such as the Little Annie Ski Basin presently being planned and developed on Castle Creek above Aspen and on National Forest property have been referred to the Region VIII office for appropriate follow-up to assure that adequate waste water treatment facilities are included in the planning of such installations.

A listing of all Federal installations known to exist in the Colorado River Basin is presently being prepared by the Municipal and Industrial Unit and will be submitted to appropriate Regional offices to assist them in determining the needs for additional waste water surveys of these facilities. Many Federal installations discharging to the Basin were not listed in the initial waste source inventory. However, all Federal facilities generating waste water are being included in the new waste source inventory. Pollution abatement and additional treatment needs for Federal installations, along with time schedules to meet these needs, will be developed in cooperation with the Regional offices as required.

Other Pollution Problems

Sediment.--The Municipal and Industrial Unit investigated a reported turbidity and siltation problem in the Roaring Fork River at Aspen, Colorado. As the snow melts on Aspen Mountain above the city, the water flows directly on to the paved streets, flushing them of dirt and other debris. This runoff is subsequently collected and discharged directly to the river via storm sewers. With additional street improvement planned, it was suggested the city confer with their consulting engineer to determine if a feasible solution for controlling, or eliminating, this sediment discharge to the river is possible.

Siltation problems interfering with trout habitat in the Frying Pan River have been brought to the attention of the Project. The problem is apparently being created by the construction activities of the Ruedi Dam and reservoir. A field investigation of this problem will be made in the near future.

A gravel washing operation on the Roaring Fork River near Basalt, Colorado was reported to be creating downstream turbidity and siltation, thus interfering with the fisheries. This operation will be kept under surveillance during the forthcoming construction season so that the problem can be fully defined.

Pesticides.--Little Project effort has been devoted to pesticide pollution in the Basin during this fiscal year.

Dr. W. M. Ingram, during the April biological survey in the Lower Colorado River Basin, met with officials of the California State Department of

Fish and Game on April 19, 1966 in Indio, California to discuss the state's proposed pesticide program in the Palo Verde area. The State of California is planning an exploratory study of pesticide concentration in fish, water, and settleable solids with some means of monitoring increased concentrations. The results of Dr. Ingram's meeting with the California officials were not available for inclusion in this document.

Laboratory Activities

The Project Laboratory, located in Salt Lake City, Utah continued to provide excellent service in analyzing radiological and inorganic samples. The Laboratory also provided technical support for field studies throughout the year by assigning personnel as required to the area evaluation teams from the Field Station.

From July 1965 through March 1966, 494 radiological samples were received by the Radiochemistry Unit and 1,469 radiochemical determinations were done on these samples.

During the same 9-months period, the Inorganic Chemistry Unit received 2,480 water (salinity) samples and performed 22,607 determinations on 2,435 samples. In addition, 30 industrial samples were received and 126 determinations of heavy metals were completed on 21 of these samples.

A backlog of salinity samples is still a problem to be resolved. Two additional chemists and a laboratory aide were recently brought into the Inorganic Unit to help alleviate this problem. An order has been placed for an atomic absorption unit for heavy metal analysis in anticipation of the industrial survey workload scheduled for FY 1967 and for the standards surveillance program which will require fast analytical support.

STORET Activities

Field Station staff members worked with the Chief, Municipal and Industrial Unit, on the development of a tabulation of river mileages, including mouths of most identified streams, bridges, and principal landmarks. This tabulation will facilitate the input to STORET of water quality data acquired by the Project, and will permit better coordination of water pollution control activities by the Basin States.

The 1:250,000 maps, on which all of the stream intersections were encoded under contract with Colorado State University, were transferred to the Field Station. These maps are being utilized in the preparation of master map sheets which will be sent to the Basic Data Branch when completed.

All chemical quality data acquired to date by the Project has been punched on STORET cards and this current status is being maintained. About half of the radium monitoring data for water samples has been transcribed to data forms, but has not been placed on punch cards. All radiological water and sediment stations have been mileage coded in STORET format. The transfer of all raw radiological data to data forms and punch cards has yet to be accomplished.

A new data management system was developed which eliminates much transcription of field data and laboratory results. A four-art form is completed by the sampler in the field at the time of sampling. All of the field data is thus encoded and ready for key punching on to STORET cards. The sampler attaches the fourth part which is backed with permanent adhesive, to the sample bottle which is then shipped to the laboratory.

The third part is retained by the sampler, and the second part is mailed to the laboratory. The first part goes to the Field Station, then to the computer sharing exchange for key punching and printout.

A new analytical data form is completed in the laboratory in free form. A copy is sent to the key punch operator for punching on STORET cards with no encoding necessary for the standard parameters. Similar systems are under study for use with heavy metals, sanitary, and radiological analyses.

We feel that the development of this data management system along with the development of computer programs which utilize the STORET cards, in lieu of separate cards for the accomplishment of Project needs, represents a significant professional and technical manpower savings, as well as a saving of overall data handling processing time.

DEPARTURE FROM FY 1966 PLANS

In planning for FY 1966, the function of the Field Station in Phoenix was reviewed. The workload in the Lower Basin was essentially complete. The problems of communication between the Field Station and Denver Headquarters were becoming more critical in view of the analytical workload being performed in Phoenix using the Computer Sharing Center in Denver and in the preparation of reports which had to dovetail into the overall program of the Project. Due to divisional needs at that time, this decision was not implemented and the Pollution Source Evaluation Section remains in Phoenix.

A significant change in Project operation resulted from the consolidation of the Pollution Control Benefits Section, the Pollution Control Section, and the Radiological Monitoring and Surveillance Unit into one section, the Pollution Damage and Control Section. This eliminated a fragmented structure and provided a flexibility in the use of engineering personnel which was difficult to achieve under the previous organization. An additional unit, the Municipal and Industrial Unit, was added to the new Pollution Damage and Control Section in November.

The change in organizational structure provided Project management with the latitude to concentrate on the completion of the single most important aspect of our engineering studies, the estimation of pollution damages in the significant water use areas in the Colorado Basin and southern California. This decision also broadened the scope of individual participation in the Pollution Damage and Control activities in that each man would be able to work in water use identification, pollution damage assessment, pollution control development, and possibly in the merging of engineering-economic data. This program has been highly successful in that completion of the preliminary damage assessment has been accomplished on schedule (April 1, 1966).

The organizational changeover was not accomplished without some personnel adjustments. This, in addition to the passage of the Federal Water Quality Act of 1965, contributed to decisions on the part of at least three senior staff members to leave the Project. These losses do have a long-range effect on the completion schedule for the Project. In essence, the administrative difficulties experienced during the past 6 months have resulted in our reevaluation of the overall Project timetable and its extension for an additional 6 months.

The use of the RSQD conductivity meters resulted in a total loss to the Project with respect to the collection of meaningful field data. The problem of ambient temperature variations in the unit remains to be solved by the manufacturer. This setback plus delays in the installation of flow-gaging stations has resulted in the determination to continue field operations in the Upper Basin through FY 1966. This decision also required the extension of laboratory activities through FY 1966.

The economic contract with the University of New Mexico was transferred to the University of Colorado with the relocation of the University of New Mexico's staff to the latter institution. An extension of the contract was negotiated with a target date of August 31, 1966. However, complete evaluation of control aspects could not be included in the contract since the Project will only be able to provide these details after that date. It is expected an additional supplemental contract will be negotiated to complete the vital work of end-point analyses. Similarly, an extension of the memo of understanding with ERS-USDA is considered essential to the completion of the Project.

PLANS AND SCHEDULES FOR WORK PROPOSED FOR FY 1967

Radiological Pollution

The development of a meaningful time schedule for the control of uranium mill tailings piles in the Colorado River Basin will be a primary objective of the Project in this area during FY 1967.

Radiological surveillance activities will be essentially identical to those carried out in FY 1966, with continuation of the established water, sediment, and effluent monitoring programs. The Chief of the Radiological Unit will be leaving the Project during the forepart of the fiscal year. When this occurs, the field aspects of this activity will be assigned to the Pollution Source Evaluation Section and the radioactivity data analysis and releases will be the responsibility of the Radiochemistry Unit of the Project Laboratory in Salt Lake City.

Mineral Pollution (Salinity)

Source Identification and Evaluation

Work will be continued on the analysis and evaluation of field data obtained from the salinity sampling programs and intensive surveys which have been conducted throughout the Basin. Flow data for water year 1966 will not be available until late spring in 1967. This will cause some delay in completion of final calculations for some areas in the Upper Basin. A limited amount of supplemental sampling may be required to complete the evaluation of salinity sources in the Upper Basin.

A monitoring program consistent with enforcement needs and for the development of water quality standards will be carried out.

Final drafts of the reports on "Statistical Analysis of Changes in Water in Relation to Time and Distance" and "Analysis of Changes in Specific Constituents" will be completed early in the fiscal year. The sections of the Project report covering natural, municipal, and industrial salinity sources should be completed by the end of the fiscal year.

Salinity Damage Assessment and Salinity Control

The principal remaining tasks in salinity damage assessment, to be carried out in fiscal year 1967, will be to recalculate salinity damages, at the water quality levels associated with the economic contractor's projections of future economic activity. It is expected that the latter projections will become available for four subbasins in July 1966 and the remaining two in September 1966. Other scheduled work in fiscal year 1967 is to collate and summarize our findings in salinity damage assessment, prepare user cost curves, write the conclusions of the study and review, edit, and reproduce the draft of the report.

Salinity control studies will also continue in fiscal year 1967. These will include the further investigation of means to keep out concentrated flows of natural brines from streams of the Basin. In conjunction with the work of the Municipal and Industrial Waste Unit, consideration will be given also to any saline wastes of industrial or municipal origin. A field study will be made in the summer of 1966 of the feasibility of recirculation of irrigation water, and the conclusions will be incorporated in the Project's general report. Close attention will be given to the physical and economic benefits of the water quality improvement incidental to large-scale importation of water into the Colorado River Basin. Finally, the reports which were prepared in draft before October 15, 1965 will be reviewed by appropriate authorities, including the Project's Technical Review Panel; revised and edited as necessary, and integrated into the Project's comprehensive report on "Pollution of the Colorado River and Its Tributaries."

Economic Studies

In FY 1967 agreement will be reached for projected 1980 and 2010 unconstrained final demand, TGO, and water-use coefficients in the Gila and Lower Main Stem Subbasins. Water supply will then be compared with water demand in the two subbasins to determine if quantity is a constraint. likewise, water quality will be projected and adjusted to projected economic activity and conversely until quality and economic activity are in approximate balance. These are the rounds of adjustments which require considerable time to accomplish.

The end point analysis will be completed for the Lower Main Stem, Gila, San Juan, and Green Subbasins which will be affected by significant degradation in projected water quality. The Upper Main Stem and Little Colorado Subbasins may not have significant degradation in water quality to require end point evaluation.

The economic contractors will prepare a final report for each of the six subbasins, then aggregate them into a composite report for the entire Colorado River Basin. The Project economists shall prepare a summary report for the Colorado River Basin on the evaluation of changes in water quantity-quality (degradation or improvement) when adjusted to economic activity. A more detailed report shall also be prepared by the Project economists from which the summary report shall be extracted.

Municipal, Industrial and Related Water Pollution Problems

The writing of the final report on municipal, industrial, and related water pollution problems in the Colorado River Basin will commence shortly after July 1, 1966.

The final inventory of municipal and industrial waste sources will be completed with updating and revisions of the draft copy being made as required. Field inspections will be made as necessary to correctly identify and locate all M&I waste sources. All waste discharges will be identified in terms of stream mileage.

General biological stream surveys of reported serious water pollution in the Upper Basin will be made during July, August, and September 1966. Dr. Ingram will again conduct these investigations and will advise the Project, on the basis of his findings, where more extensive waste source and water pollution studies should be made. The Project will again request the SEC technical assistance in conducting the more extensive surveys, if needed. It is the Project's plan to complete all M&I pollution survey field work in the Upper Basin during the summer and fall of 1966.

Analyses and evaluation of M&I pollution data will be accomplished and reported in the final report. Pollution abatement programs will be developed in cooperation with the concerned states. Guidelines for solving the more complicated waste discharge and pollution problems, such as those from mining and milling operations, will be developed and made available to the states and industries.

Existing water quality data shows that streams heading in the San Juan Mountains of southwestern Colorado often contain heavy metals in concentrations in excess of the PHS Drinking Water Standards at points of use as water supply. State game officials have noted that certain of the streams will not support game fish. It has been shown by the Project's Animas-La Plata study plus other studies that streams in the area are degraded. As part of the Field Station responsibility of identifying waste sources throughout the Colorado River Basin, plans are underway to conduct an intensive survey to ascertain the location and magnitude of these sources, as soon as the sources are accessible this summer.

This survey is planned for July and August 1966 and will consist of determining the heavy metals content of streams and effluents in the area by means of a Hach Chemical Company colorimeter kit equipped for heavy metals, supported by laboratory analysis of samples from key stations to be selected as the survey proceeds. In the field, samples will be tested for barium, boron, chromium, copper, cyanide, fluoride, iron, manganese, pH, selenium, silver, and sulphate. In addition, laboratory samples will be checked for arsenic, lead, and zinc. Flows will be gaged or measured by suitable means. Waters to be surveyed will consist of tributary streams, drainage from abandoned mines, and mine drainage and effluents from operating mines and mills along the Animas River above Durango, the La Plata River above Hesperus, the Dolores River above Dolores, the San Miguel River above Placerville, and the Uncompahgre River above Ouray.

Laboratory Activities

The Project Laboratory at Salt Lake City will continue at its present level of operation during FY 1967. The radiological monitoring program and the sediment surveys will utilize the radiological unit's full capabilities. This unit will also be responsible for the preparation and completion of the laboratory methods section on radiological analyses in the Project final report during FY 1967.

The Inorganic Unit will address itself to the surveillance network requirements of the Project, the municipal and industrial waste surveys scheduled for FY 1967, and the developing needs for the water quality standards program for the Basin. In addition, this unit will continue to provide inorganic analytical support to the South Platte River Project.

An important adjunct to the Laboratory will be the installation and use of an atomic absorption unit for heavy metal analysis. With metals mining and milling a major industry in the Colorado River Basin, the addition of this analytical tool will provide important support in our surveillance and water quality standards activities.

Other Activities

The Project may provide technical assistance to the Basin states in their development of water quality standards. With the Project's knowledge of the Basin's water quality problems through various data collected, it is thought that they will look for assistance in establishing pollution control standards.

STORET

The transfer of stream intersection codes from Project maps to STORET maps will be completed and the STORET maps will be sent to the Basic Data Office. The Data Analysis Unit will continue input of all water quality data acquired by the Project.

NARRATIVE BUDGET JUSTIFICATION

FY 1966

The most significant gains in the pollution control study of the Colorado River Basin were made during this year. Field studies of salinity sources in the Upper Colorado Basin were essentially completed. Water-use damage assessment for the most significant areas was completed on April 1, 1966. The Project staff and the economic contractors developed a methodology for determining the effects of water quantity and quality on the economy of the Basin. A model test on the Lower Main Stem Subbasin of this methodology was made successfully with relatively few technical problems developing. A reorganization of the engineering components resulted in a single unit organization for those activities in the Denver office. This provides greater flexibility in operation and has resulted in significant improvement in work output. The Project's field activities delineated many municipal and industrial trouble spots in the Upper Basin. The overall problem was discussed in a public meeting in Grand Junction, Colorado. The Project was charged at that time to do definitive municipal and industrial waste surveys within the Colorado River Basin. These surveys will be continued through this year and into FY 1967. The release of the Project's report "Disposition and Control of Uranium Mill Tailings Piles in the Colorado River Basin" resulted in a public clamor for action. The industry is now developing programs for control of this residual source of radioactivity.

FY 1967

Evaluation of all field and analytical data will be completed during this fiscal year. Intensive surveys of municipal and industrial waste sources will be completed and will include a biological assessment of the conditions of the Basin's streams below critical waste discharges. A detailed waste inventory will be completed during this year. Studies on control of salinity sources in the Basin will be completed. The results of these studies will be integrated with the engineering-economic model and evaluated. TDS constituent analyses will be completed. A surveillance network will be established for the Basin to supplement the existing radiological monitoring network. The Project's final report will be in preparation during this fiscal year. The level of activities for this year is significantly increased over the planned program originally envisioned with a consequent substantial increase in budget requirements. This has become necessary primarily due to the municipal and industrial, nutrient, and other studies which the Conferees and the Project have recognized as important. Coupled with the passage of the Federal Water Quality Act and its standards provision the decision dictated the maintenance of the laboratory capability and a viable field organization. A phase out of many of the Project activities will be underway providing no new directives are issued by the Conferees.

FY 1968

The final report will be completed and submitted to the Conferees by mid-year. Recommendations for an effective water pollution control program will be developed for inclusion in the final report to the Enforcement Conference. Subject to water quality standards, comprehensive and other program needs, all staff, except radiological and certain administrative field and laboratory personnel, will have been transferred or released from duty by mid-FY 1968.

TECHNICAL BACKUP REQUIREMENTS

FY 1966

During the year assistance was provided the Project by the Biology and Chemistry Unit of TA&IA, SEC, to survey the Lower Main Stem of the Colorado River, including Lake Mead. The TA&IA is also supporting the Project in surveys of M&I and recreational pollution problems in the same area. Specific surveys of the Las Vegas Wash area in Nevada, Lake Havasu and Lake Moovalya on the Lower Main Stem are scheduled for May 1966.

The Physical and Engineering Sciences Unit of TA&IA cooperated in the preparation and review of the Project report, "Disposition and Control of Uranium Mill Tailings Piles in the Colorado River Basin." This unit is also providing review services in the development of the radiological segment of the Project final report.

The Robert S. Kerr Laboratory provided assistance to the State of New Mexico on specific municipal waste discharges in the San Juan Subbasin as the result of field surveys by the Project staff. The Laboratory also participated in discussions with the oil transmission line industry to explore possible control programs to minimize spills resulting from accidental breaks in high pressure oil transmission lines.

The Region VII, VIII, and IX offices provided information on construction grants and Federal installations in the Colorado River Basin.

The Technical Review Panel was established to provide the Project with an independent evaluation resource. Two review sessions have been scheduled for this year.

FY 1967

The Project will need SEC to provide direct technical assistance in biological and M&I surveys scheduled for the Upper Colorado Basin and for the Yuma, Arizona area. Consultative services will also be needed in the development of the final report on radiological activities and on the current program for control of uranium mill tailings piles.

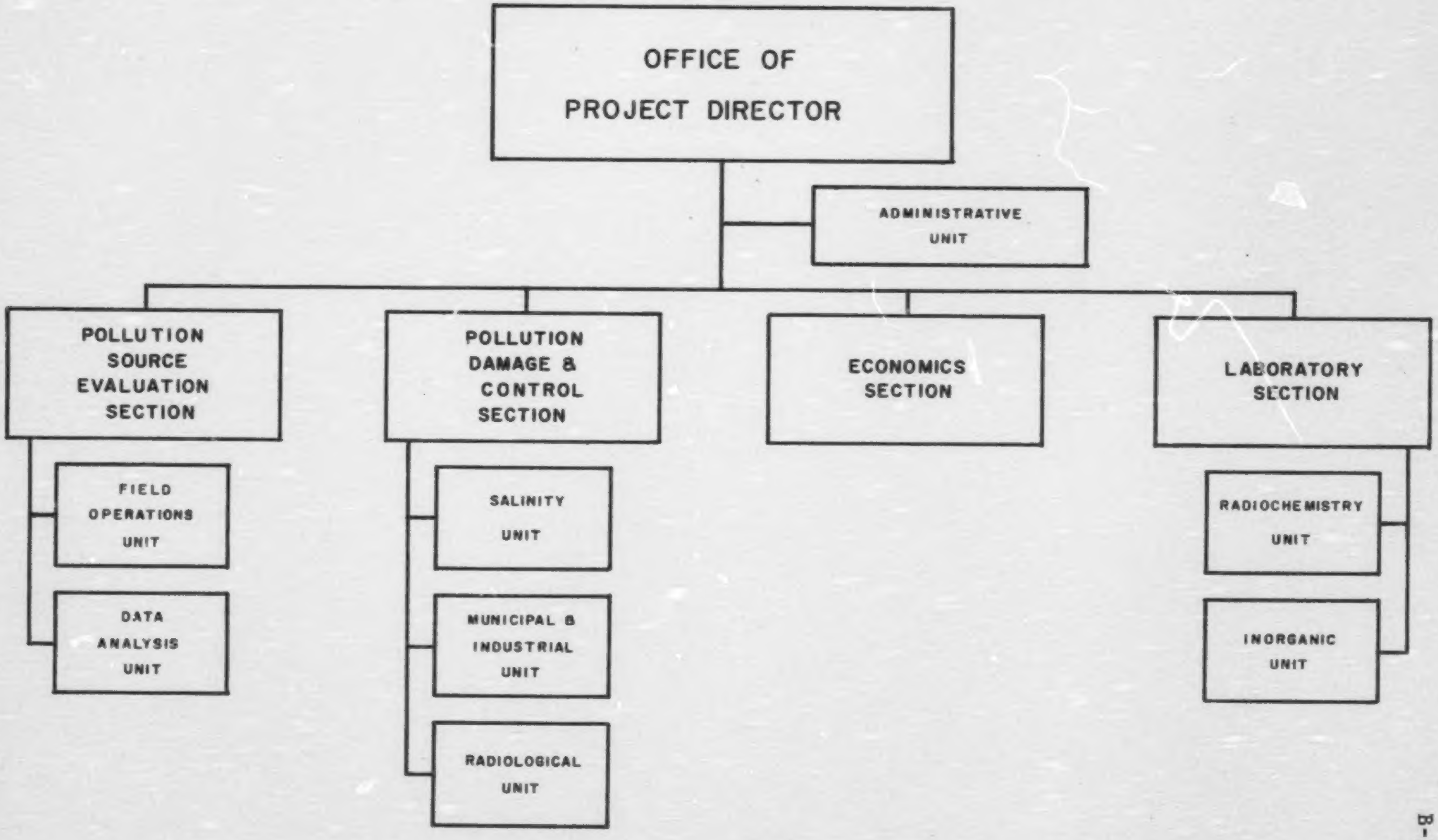
Headquarters will provide the Project with guidance on the development water quality standards requirements and consultative support on current economic-engineering studies.

The Project Technical Review Panel will continue to provide an independent technical review on specific methodological approaches developed by the Project.

SECTION B
ORGANIZATION AND MANAGEMENT

ORGANIZATION CHART

COLORADO RIVER BASIN WATER QUALITY CONTROL PROJECT


OFFICE OF PROJECT DIRECTOR
ADMINISTRATIVE UNIT
POLLUTION SOURCE EVALUATION SECTION
FIELD OPERATIONS UNIT
DATA ANALYSIS UNIT
POLLUTION DAMAGE & CONTROL SECTION
SALINITY UNIT
MUNICIPAL & INDUSTRIAL UNIT
RADIOLOGICAL UNIT
ECONOMICS SECTION
LABORATORY SECTION
RADIOCHEMISTRY UNIT
INORGANIC UNIT

FUNCTIONAL STATEMENT
for
Colorado River Basin Water Quality Control Project

1. Pursuant to section 8(a) of the Federal Water Pollution Control Act determines the location, magnitude, nature, and causes of interstate pollution of the Colorado River and its tributaries.
2. Determines and evaluates the nature and magnitude of the damages to water users caused by radioactivity, salinity, and other types of pollution.
3. Develops and evaluates methods of controlling or minimizing pollution.
4. Recommends control or other measures justified by benefits, economic or otherwise, that will accrue from minimizing pollution.

OFFICE OF THE PROJECT DIRECTOR (DENVER, COLORADO):

1. Interprets program policy and establishes Project objectives.
2. Formulates plans and guidelines for the accomplishment of these objectives.
3. Directs and administers Project activities.
4. Reports Project accomplishments to higher authority.
5. Represents the Project in relationships with Federal, state, and local agencies and with the public.
6. Coordinates preparation of preliminary and final reports on pollution of the Colorado River and its tributaries.

Administrative Unit (Denver, Colorado):

Provides administrative services to the Project.

POLLUTION SOURCE EVALUATION SECTION (PHOENIX, ARIZONA):

Plans and conducts field investigations and makes engineering and statistical studies to identify and evaluate sources of salinity and other types of pollution in the Colorado River Basin. Prepares technical reports pertaining to these activities.

Field Operations Unit (Phoenix, Arizona and Grand Junction, Colorado):

1. Plans and conducts stream sampling programs and field surveys to obtain up-to-date data on the location, magnitude, nature and causes of salinity sources in the Basin.
2. Conducts stream sampling programs and field surveys to provide data on the location, nature, and magnitude of other types of pollution in the Basin.

Data Analysis Unit (Phoenix, Arizona):

1. Assembles and evaluates existing data pertaining to salinity sources in the Colorado River Basin.
2. Plans and conducts statistical and related studies of existing and current data pertaining to salinity sources to determine changes in stream water quality with respect to time and distance as well as specific constituents.
3. Plans and conducts engineering studies to evaluate the significance and magnitude of natural, municipal, industrial, and agricultural sources of salinity.

POLLUTION DAMAGE AND CONTROL SECTION (DENVER, COLORADO):

Plans and conducts detailed engineering studies on water uses in the Colorado River Basin, nature and magnitude of damages to water users caused by salinity, municipal, industrial, nutrient and radiological pollution, and measures and programs for controlling or minimizing this pollution.

Prepares technical reports pertaining to these activities.

Salinity Unit (Denver, Colorado):

1. Determines and evaluates the nature and magnitude of the damages to water users caused by salinity.
2. Develops methodology for estimating the physical and economic magnitude of these damages for the principal water service areas of the Colorado River.
3. Develops and evaluates measures for controlling or minimizing salinity from agricultural, municipal, industrial, and natural sources.
4. Investigates factors that may affect salinity concentration such as surface evaporation, evapotranspiration by natural vegetation and transbasin diversions and evaluates methods for minimizing the ill effects of these concentrating factors.
5. Develops cost estimates for measures and programs for controlling or minimizing salinity pollution.
6. Determines and evaluates the relationships which exist among water quality, damages, and control costs.
7. In cooperation with the Economics Section, develops and evaluates methodology for integrating results of economic contractor's studies with engineering data obtained by the Project.

Municipal and Industrial Unit (Denver, Colorado):

1. Assembles and evaluates existing data pertaining to municipal industrial, and nutrient pollution in the Colorado River Basin.
2. In cooperation with the Pollution Source Evaluation Section and Sanitary Engineering Center plans bacteriological, biological, and

industrial waste studies to obtain up-to-date data on these types of pollution.

3. Determines and evaluates the nature and magnitude of the damages to water users caused by municipal, industrial, and nutrient pollution.
4. Determines measures and programs needed for controlling or minimizing municipal, industrial, and nutrient pollution.
5. In cooperation with state water pollution control agencies, develops recommended time schedules for control of municipal and industrial pollution.

Radiological Unit (Denver, Colorado):

1. Develops programs for providing continuing surveillance of radiological pollution in the Colorado River Basin.
2. In cooperation with the Pollution Source Evaluation Section, develops and maintains a sampling program of radiological pollution sources in the Basin.
3. In cooperation with the Sanitary Engineering Center, plans and conducts special studies of radiological pollution.
4. Evaluates and reports results of the surveillance program and special studies.
5. Develops and evaluates measures for controlling radiological pollution.
6. Develops and evaluates cost estimates for measures and programs for controlling or minimizing radiological pollution.

ECONOMICS SECTION (DENVER, COLORADO):

1. In cooperation with the Pollution Damage and Control Section, develops and evaluates methodology for integrating results of economic contractor's studies with engineering data obtained by the Project.
2. Provides liaison for scheduling of work and date interchange between economic contractors and the Project.
3. In cooperation with the Pollution Damage and Control Section, prepares final benefit-cost relationships for changes in water quality based upon alternative control proposals and adjustments in water uses.
4. Prepares technical reports covering economic activities as necessary to accomplish Project objectives.

LABORATORY SECTION (SALT LAKE CITY, UTAH):

Provides laboratory services in radiochemistry, inorganic chemistry and related sanitary sciences and prepares technical reports pertaining to those activities as required to accomplish Project objectives.

Radiochemistry Unit (Salt Lake City, Utah):

1. Provides laboratory support in radiochemistry.
2. Develops improved analytical procedures and new methodology in this area.

Inorganic Chemistry Unit (Salt Lake City, Utah):

1. Provides laboratory support in inorganic chemistry.
2. Develops improved analytical procedures and new methodology in this area.

STAFFING ROSTER
COLORADO RIVER BASIN WATER QUALITY CONTROL PROJECT

Filled Permanent Positions: 1966-52; 1967-52

April 1966

Unit & Position Title	Grade or Rank	Series	Position Number	Duty Station	Incumbent	Remarks
OFFICE OF THE PROJECT DIRECTOR						
Project Director (Supv San Eng)	GS-15/SEDIR	819	---	Denver, Colorado	Rademacher, John M.	
Deputy Project Dir. (Supv San Eng)	GS-14	819	EH-63-553	Denver, Colorado	Rainey, M. B.	
Secretary	GS-5	318	161	Denver, Colorado	Braley, Donna J.	
Administrative Unit						
Administrative Officer	GS-11	341	EH-65-361	Denver, Colorado	Metzler, A. E.	
Clerk-Steno	GS-4	312	185	Denver, Colorado	Doan, C. Ann	
POLLUTION SOURCE EVALUATION SECTION						
Chief (Supv San Eng)	GS-13/SASE	819	---	Phoenix, Arizona	Blackman, William C.	
Clerk-Steno	GS-5	312	64-21	Phoenix, Arizona	Shiels, V. Louise	
Clerk-Steno	GS-4	312	167	Phoenix, Arizona	Leaman, Virginia A.	
Field Operations Unit						
Chief (San Eng)	GS-12/SASE	819	---	Phoenix, Arizona	Rouse, James V.	Performs also as Asst. Chief of Section.
Sanitary Engineer	GS-9/SASE	819	---	Grand Junction, Colorado	Yonikas, Patrick J.	
Engineering Technician	GS-7	802	EH-64-392	Grand Junction, Colorado	Korolevich, E. R.	
Engineering Technician	GS-5	802	EH-64-684	Phoenix, Arizona	Pemberton, Charles A.	
Aquatic Sample Collector	WB-4	3501	EH-64-21	Phoenix, Arizona	Hall, Benjamin L.	
Aquatic Sample Collector	WB-4	3501	EH-64-21-IA	Grand Junction, Colorado	Walz, Laurence R.	2 Aquatic Sampler positions previously shown as temporary positions.
Aquatic Sample Collector	WB-4	3501	EH-64-21-IA	Grand Junction, Colorado	Newhoff, D. D.	
Data Analysis Unit						
Chief (San Eng)	GS-11/SASE	819	---	Phoenix, Arizona	Schillinger, G. R.	
Civil Engineer	GS-7	810	EH-65-540	Phoenix, Arizona	Shafer, William H.	
Engineering Technician	GS-5	802	EH-64-21-IA	Phoenix, Arizona	Anderson, C. P.	

COLORADO RIVER BASIN WATER QUALITY CONTROL PROJECT - STAFFING ROSTER (continued)

April 1966

Unit & Position Title	Grade or Rank	Series	Position Number	Duty Station	Incumbent	Remarks
POLLUTION DAMAGE & CONTROL SECTION						
Chief (Supv San Eng)	GS-14/SEDIR	819	---	Denver, Colorado	Coffey, Philip J.	
Clerk-Steno	GS-4	312	256	Denver, Colorado	Squires, Marjorie	
Clerk-Typist	GS-4	322	215	Denver, Colorado	Spedon, Mary G.	
Salinity Unit						
Chief (San Eng)	GS-13	819	---	Denver, Colorado	Vacant	Performs also as Asst. Sec. Chief
Sanitary Engineer	GS-12/SE	819	---	Denver, Colorado	Reed, Lloyd A.	Trans. 5/1/66. Pos. not to be filled
Sanitary Engineer	GS-12	819	---	Denver, Colorado	Crabtree, Robert G.	Est. EOD 4/10/66
Sanitary Engineer	GS-12/SASE	819	---	Denver, Colorado	Freeman, J. Russell	
Geologist	GS-12	1350	BSS-5179	Denver, Colorado	Spiegel, Sidney J.	
Sanitary Engineer	GS-11	819	---	Denver, Colorado	Vacant	2 GS-11 Sanitary Engineer positions not to be filled until anticipated trf. & termination occur.
Sanitary Engineer	GS-11	819	---	Denver, Colorado	Vacant	
Sanitary Engineer	GS- 9/ASE	819	---	Denver, Colorado	Arden, James E.	
Sanitary Engineer	GS- 9/ASE	819	---	Denver, Colorado	Bennett, Francis W.	
Hydrologist	GS- 9	1315	EH-65-332	Denver, Colorado	Baez, Cesar P.	
Municipal & Industrial Unit						
Chief (San Eng)	GS-12/SASE	819	---	Denver, Colorado	Kirkpatrick, Kenton	
Sanitary Engineer	GS- 9	819	---	Denver, Colorado	Clapper, Thomas L.	Est. EOD 4/10/66
Radiological Unit						
Chief (San Eng)	GS-12/SASE	819	---	Denver, Colorado	Wruble, Donald T.	
ECONOMICS SECTION						
Chief Economist	GS-13	110	BSS-4178	Denver, Colorado	Smith, Carl B.	
Economist	GS-12	110	EH-65-2817	Denver, Colorado	Collins, George G.	
Clerk-Steno	GS- 4	312	65-42	Denver, Colorado	McAnally, Shirley	

COLORADO RIVER BASIN WATER QUALITY CONTROL PROJECT - STAFFING ROSTER (continued)

April 1966

Unit & Position Title	Grade or Rank	Series	Position Number	Duty Station	Incumbent	Remarks
LABORATORY SECTION						
Laboratory Director	GS-15	1320	BSS-3631	Salt Lake City, Utah	Rushing, D. E.	
Administrative Aid	GS-6	301	194	Salt Lake City, Utah	Zeman, Blanche	
Clerk-Steno	GS-4	312	173	Salt Lake City, Utah	Madsen, Janice C.	
Radiochemistry Unit						
Supervisory Chemist	GS-13/SHSO	1320	---	Salt Lake City, Utah	Talvitie, Niilo A.	
Chemist, Analytical	GS-11	1320	BSS-4692	Salt Lake City, Utah	Garcia, William J.	
Chemist, Analytical	GS-11	1320	BSS-4692-IA	Salt Lake City, Utah	Demint, Robert J.	
Chemist, Analytical	GS-11	1320	BSS-4692-IA	Salt Lake City, Utah	Clark, Donald A.	
Physical Science Technician	GS-5	1311	269	Salt Lake City, Utah	Sorenson, Boyd C.	
Physical Science Aid	GS-4	1311	247	Salt Lake City, Utah	Farmer, Richard J.	
Inorganic Unit						
Supervisory Chemist	GS-13	1320	BSS-4406	Salt Lake City, Utah	Connor, John G.	
Chemist	GS-12	1320	EH-64-573	Salt Lake City, Utah	Jarrell, Raymond E.	
Chemist, Analytical	GS-9/AHSO	1320	---	Salt Lake City, Utah	Freking, Ronald J.	
Chemist, Analytical	GS-9	1320	BSS-4410	Salt Lake City, Utah	Keisler, Hans	
Chemist	GS-7	1320	EH-66-256	Salt Lake City, Utah	Tauer, Robert C.	
Chemist	GS-7	1320	EH-66-256-IA	Salt Lake City, Utah	Vacant	
Physical Science Aid	GS-4	1311	205	Salt Lake City, Utah	Smith, Fred	
Physical Science Aid	GS-4	1311	205-IA	Salt Lake City, Utah	Park, Douglas L.	Est. EOD 4/10/66
**Chemist	GS-7	1320	BSS-6005	Salt Lake City, Utah	Staker, W. L.	Est. EOD 4/10/66 for 90 days
**Physical Science Aid	GS-4	1311	205-IA	Salt Lake City, Utah	Vacant	Est. EOD 4/24/66 for 90 days
**Physical Science Aid	GS-4	1311	205-IA	Salt Lake City, Utah	Vacant	Est. EOD 4/24/66 for 90 days

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** Other than permanent position

BUDGET - FY 66 AND 67

Analysis by Object Class

April 1966

Region VIII - Denver, Colorado

Colorado River Basin Water Quality Control Project

Request		1966	1967	Estimate 1966	Estimate 1967	Increase or Decrease
11	Personnel Compensation (Total)			$382,198	$418,935	+36,737
12	Personnel Benefits			54,495	38,329	-16,166
21	Travel					
	Change of Station Including Dependents and Dislocation Allowance			2,563	2,000	-563
	Car Rental (All Sources)			5,619	5,500	-119
	Other Travel			47,071	45,300	-1,771
22	Transportation of Things					
	Trucks and Vehicles			23,394	21,300	-2,094
	Change of Station			6,592	5,000	-1,592
	Other			3,600	2,000	-1,600
23	Rents, Communications and Utilities			6,486	7,200	+714
24	Printing and Reproduction			4,000	6,000	+2,000
25	Other Services					
	Contracts					
	University of Colorado			52,000	25,000	-27,000
	Other than Contracts			68,390	44,000	-24,390
	Department of Agriculture (ERS)	$47,500	$25,000			
	Sample Collectors	5,062	5,000			
	Technical Services	4,000	4,000			
	Instrument Measurement and Maintenance	1,500	1,500			
	Stream Measurements (USGS)	2,450	1,500			
	STORET and/or ADP	4,000	5,000			
	Miscellaneous	3,878	2,000			
	Subtotal	$68,390	$44,000			

BUDGET (Continued)

Request for Funds, FY 1966 and 1967

April 1966

Region VIII - Denver, Colorado

Colorado River Basin Water Quality Control Project

	Estimate 1966	Estimate 1967	Increase or Decrease
26 Supplies and Materials	15,372	15,436	+664
31 Equipment	13,220	1,000	-1,220
TOTAL	$685,000	$637,000	-48,000

Adjustment for FY 1966:

FY 1966 allowance	$678,000
Funds to be transferred from South Platte Project to cover costs of 3 laboratory positions transferred from South Platte Project to Colorado River Basin Water Quality Control Project	4,000
Funds to be transferred from Basic Data, Region VIII to reimburse for STORET work performed by Project	3,000
	$685,000

Adjustment for FY 1967:

FY 1967 planning allowance	$463,000
Additional funds required to accomplish Project program as currently planned	174,000
	$637,000

April 1, 1966

Region VIII, Denver, Colorado

PERSONNEL SERVICES FOR FY 1966

Colorado River Basin Water Quality Control Project

Position Title	Incumbent	Grade or Rank as of 4/1/66	Current Annual Rate	FY 1966 Costs Compensation	FY 1966 Costs Benefits	Remarks
Permanent Positions						
Project Director	Rademacher, J. M.	SEDIR +12	9,583	9,492	2,837	
Deputy Project Director	Rainey, M. B.	GS-14/5	16,712	16,301	1,197	
Administrative Officer	Metzler, A. E.	GS-11/1	8,961	8,721	678	
Secretary	Braley, Donna	GS-5/7	6,207	6,080	418	
Clerk-Steno	Doan, Ann	GS-4/6	5,421	4,147	332	EOD 9/26/65
Clerk-Steno	Sneddon, Evelyn	GS-4/4	---	948	75	Terminated 8/28/65
Chief, Pollution Source Evaluation Section	Blackman, W. C.	SASE +16	8,345	8,266	2,352	
Secretary	Shiels, Virginia	GS-5/2	5,352	5,314	446	
Clerk-Steno	Leaman, Virginia	GS-4/10	6,045	6,013	448	
Chief, Field Operations Unit	Rouse, J. V.	SASE +4	6,782	6,485	2,357	
Sanitary Engineer	Yonikas, P. J.	GS-9/3 P	8,495	6,742	1,957	Converted CO to CS 2/26/66
Engineering Technician	Korolevich, E. R.	GS-7/2	6,476	6,430	475	
Engineering Technician	Pemberton, C. A.	GS-5/1	5,181	1,574	133	EOD 3/14/66
Aquatic Sample Collector	Hall, B. L.	WB-4/3	2.54/hr	5,304	308	
Aquatic Sample Collector	Walz, L. R.	WB-4/1	2.09/hr	3,232	129	EOD 9/27/65
Aquatic Sample Collector	Newhoff, D. D.	WB-4/1	2.09/hr	1,655	82	EOD 2/13/66
Chief, Data Analysis Unit	Schillinger, G. R.	SASE +4	6,782	6,120	2,357	
Civil Engineer	Shafer, W. H.	GS-7/1 P	7,304	7,053	566	
Engineering Technician	Anderson, C. A.	GS-5/3	5,523	3,384	282	EOD 11/21/65
Sanitary Engineer	Todd, A. W.	SASE +2	---	1,762	676	Separated 9/5/65 incl. LS pay.
Laboratory Mechanic	Woeltje, D. R.	GS-7/1	---	1,676	90	Terminated 10/8/65
Engineering Technician	Lowe, D. R.	GS-5/1	---	2,030	108	Employed 9/16/65 to 1/28/66
Chief, Pollution Damage & Control Section	Coffey, P. J.	SEDIR +20	13,039	12,197	2,862	
Clerk-Steno	Squires, Marjorie	GS-4/7	5,577	5,517	412	
Clerk-Steno	Spedon, Mary	GS-4/7	5,577	5,446	407	

Region VIII, Denver, Colorado

PERSONNEL SERVICES FOR FY 1966

April 1, 1966

Colorado River Basin Water Quality Control Project

Position Title	Incumbent	Grade or Rank as of 4/1/66	Current Annual Rate	FY 1966 Costs		Remarks
				Compensation	Benefits	
Permanent Positions						
Chief, Salinity Unit	Vacant	GS-13	12,510	914	67	Est. EOD 6/5/66
Sanitary Engineer	Reed, L. A.	SE +8	7,628	6,284	2,119	Trans. Portland, Ore. 5/1/66
Sanitary Engineer	Freeman, J. R.	SASE +4	6,782	5,652	1,997	EOD 9/1/65
Sanitary Engineer	Crabtree, R. G.	GS-12	10,619	2,412	184	Est. EOD 4/10/66
Sanitary Engineer	Vacant	GS-11 P	9,267	678	48	Est. EOD 6/5/66
Sanitary Engineer	Vacant	GS-11 P	9,267	678	48	Est. EOD 6/5/66
Sanitary Engineer	Bennett, F. W.	ASE -2	4,111	3,988	1,223	
Sanitary Engineer	Arden, J. E.	ASE -2	4,111	2,056	1,088	EOD 1/1/66
Geologist	Spiegel, S. J.	GS-12/4	11,723	11,661	879	
Hydrologist	Baez, C. P.	GS-9/1 P	7,987	7,761	612	
Chief, Municipal & Industrial Unit	Kirkpatrick, K.	SASE +4	6,782	5,543	1,997	EOD 9/1/65
Sanitary Engineer	Clapper, T. J.	GS-9/4 P	8,749	1,987	154	Est. EOD 4/10/66
Chief, Radiological Unit	Wruble, D. T.	SE +4	7,171	6,595	2,394	Promotion to SE 4/1/66
Sanitary Engineer	Ortolano, L.	SASE +2	---	683	241	Separated 7/3/66 incl. LS pay.
Sanitary Engineer	Jeffrey, E. A.	SSE +18	---	5,540	1,278	Transferred 1/7/66
Sanitary Engineer	Yorke, C. A.	SASE +2	---	3,933	1,645	Separated 2/28/66 incl. LS pay.
Hydrologist	Mumma, G. L.	GS-14/2	---	7,097	387	Term. 11/8/65 incl. LS pay.
Chief, Economics Section	Smith, C. B.	GS-13/4	13,815	13,732	1,020	
Economist	Collins, G. G.	GS-12/4	11,723	11,333	858	
Clerk-Steno	McAnally, Shirley	GS-4/6	5,421	3,908	254	EOD 10/10/65
Laboratory Director	Rushing, D. E.	GS-15/4	18,825	18,512	1,347	
Administrative Aide	Zeman, Blanche	GS-6/6	6,662	6,557	483	
Clerk-Steno	Madsen, Janice	GS-4/4	5,109	4,941	419	

Region VIII, Denver, Colorado

PERSONNEL SERVICES FOR FY 1966

April 1, 1966

Colorado River Basin Water Quality Control Project

Position Title	Incumbent	Grade or Rank as of 4/1/66	Current Annual Rate	FY 1966 Costs Compensation	FY 1966 Costs Benefits	Remarks
Permanent Positions						
Supervisory Chemist, Radiochemistry Unit	Talvitie, N. A.	SHSO +20	11,146	11,040	2,687	
Chemist Analytical	Garcia, W. J.	GS-11/6 P	10,797	10,733	816	
Chemist Analytical	Demint, R. J.	GS-11/6 P	10,797	10,733	816	
Chemist Analytical	Clark, D. A.	GS-11/4 P	10,185	10,023	766	
Physical Science Technician	Sorenson, B. C.	GS-5/2	5,352	5,314	365	
Physical Science Aid	Farmer, R. J.	GS-4/4	5,109	4,993	379	
Supervisory Chemist, Inorganic Unit	Connor, J. C.	GS-13/4	13,815	13,732	1,020	
Chemist, Analytical	Jarrell, R. E.	GS-12/4	11,723	11,529	870	
Chemist, Analytical	Freking, R. J.	AHSO +3	6,127	5,820	2,348	
Chemist, Analytical	Keisler, H.	GS-9/6 P	9,257	9,205	712	
Chemist, Analytical	Tauer, R. C.	GS-7/1 P	7,304	1,987	158	EOD 3/27/66
Physical Science Aid	Vacant	GS-7 P	7,304	547	40	Est. EOD 6/5/66
Physical Science Aid	Smith, F. A.	GS-4/1	4,641	2,837	234	EOD 11/21/65
	Park, D. L.	GS-4/1	4,641	1,053	152	Est. EOD 4/10/66
Physical Science Aid	Criddle, Louise M.	GS-4/1	---	722	63	Terminated 8/28/65
Temporary Positions						
Clerk-Typist	Burton, Pamela	GS-2/1	---	562	20	Summer employee 7/6/65-9/3/65
Chemist	Staker, W. L.	GS-7/1 P	7,304	1,699	96	Est. EOD 4/10/66
Physical Science Aid	Vacant	GS-4/1	4,641	875	55	Est. EOD 4/24/66
Physical Science Aid	Vacant	GS-4/1	4,641	875	55	Est. EOD 4/24/66
Aquatic Sampler	Sawtelle, D. C.	WB-4/3	---	2,642	86	Terminated 12/31/65
Aquatic Sampler	Senn, C. S.	WB-4/1	---	943	31	Terminated 9/11/65
				382,198	54,495	436,693 TOTAL

FY 1966 costs include promotions, step in grade, and years of service increases

April 1, 1966

PERSONNEL SERVICES FOR FY 1967

Region VIII, Denver, Colorado

Colorado River Basin Water Quality Control Project

Position Title	Incumbent	Grade or Rank as of 7/1/66	Current Annual Rate	FY 1967 Costs Compensation	FY 1967 Costs Benefits	Remarks
Existing Positions						
Project Director	Rademacher, J. M.	GS-15/1	17,055	17,055	1,249	Converts from CO by 7/1/66
Deputy Project Director	Rainey, M. B.	GS-14/5	16,712	16,712	1,223	
Administrative Officer	Metzler, A. E.	GS-11/1	8,961	9,267	716	Step Increase 9/66
Secretary	Braley, Donna	GS-5/7	6,207	6,207	426	
Clerk-Steno	Doan, Ann	GS-4/6	5,421	5,421	433	
Chief, Pollution Source Evaluation Section	Blackman, W. C.	SASE +16/GS-13	8,345	8,345	2,462	Detailed to FWPCA as CO
Secretary	Shiels, Virginia	GS-5/2	5,352	5,497	458	Step Increase 11/66
Clerk-Steno	Leaman, Virginia	GS-4/10	6,045	6,045	450	
Chief, Field Operations Unit	Rouse, J. V.	GS-11/3P	10,619	10,619	807	Converts from CO by 7/1/66
Sanitary Engineer	Yonikas, P. J.	GS-9/3P	8,495	8,603	618	Step Increase 3/67
Engineering Technician	Korolevich, E. R.	GS-7/2	6,476	6,670	491	Step Increase 8/66
Engineering Technician	Pemberton, C. A.	GS-5/1	5,181	5,181	418	
Aquatic Sample Collector	Hall, B. L.	WB-4/3	2.54/hr	5,304	304	
Aquatic Sample Collector	Walz, L. R.	WB-4/1	2.09/hr	4,364	240	
Aquatic Sample Collector	Newhoff, D. D.	WB-4/1	2.09/hr	4,364	240	
Chief, Data Analysis Unit	Schillinger, G. R.	SASE +4/GS-9	6,782	8,825	1,080	Converts to GS-9/8P 10/66 Compl. 2 years
Civil Engineer	Shafer, W. H.	GS-7/1P	7,304	7,658	612	Step Increase 11/66
Engineering Technician	Anderson, C. A.	GS-5/3	5,523	5,523	466	

Region VIII, Denver, Colorado

PERSONNEL SERVICES FOR FY 1967

April 1, 1966

Colorado River Basin Water Quality Control Project

Position Title	Incumbent	Grade or Rank as of 7/1/66	Current Annual Rate	FY 1967 Costs		Remarks
				Compensation	Benefits	
Existing Positions						
Chief, Pollution Damage and Control Section	Coffey, P. J.	SEDIR +20/GS-14	13,039	13,039	2,892	Detailed to FWPCA as CO
Clerk-Steno	Squires, Marjorie	GS-4/7	5,577	5,577	417	
Clerk-Steno	Spedon, Mary	GS-4/7	5,577	5,577	417	
Chief, Salinity Unit	Vacant	GS-13/1	12,510	12,510	937	
Sanitary Engineer	Freeman, J. R.	GS-12/1	10,619	10,619	807	Converts from CO by 7/1/66
Sanitary Engineer	Crabtree, R. G.	GS-12/1	10,619	10,788	818	Step increase 4/67
Sanitary Engineer	Vacant	GS-11/1P	9,267	9,267	716	
Sanitary Engineer	Vacant	GS-11/1P	9,267	9,267	716	
Sanitary Engineer	Bennett, F. W.	ASE -2/GS-9	4,111	2,110	1,034	Separates CO 1/5/67, comp. 2 yrs.
Sanitary Engineer	Arden, J. E.	GS-9/2P	8,241	8,241	599	Converts from CO by 7/1/66
Hydrologist	Baez, C. P.	GS-9/1P	7,987	8,240	647	Step increase 8/66
Chief, Municipal and Industrial Unit	Kirkpatrick, K.	GS-12/1	10,619	10,619	807	Converts from CO by 7/1/66
Sanitary Engineer	Clapper, T. J.	GS-9/4P	8,749	8,749	683	
Chief, Radiological Unit	Wruble, D. T.	SASE +5/GS-12	7,171	1,195	406	Transfers to Rad Health 9/1/66
Chief, Economics Section	Smith, C. B.	GS-13/4	13,815	14,085	1,043	Step increase 1/67
Economist	Collins, G. G.	GS-12/4	11,723	11,723	882	
Clerk-Steno	McAnally, Shirley	GS-4/6	5,421	5,421	352	

PERSONNEL SERVICES FOR FY 1967

Region VIII, Denver, Colorado

April 1, 1966
Colorado River Basin Water Quality Control Project

Position Title	Incumbent	Grade or Rank as of 7/1/66	Current Annual Rate	FY 1967 Costs Compensation	FY 1967 Costs Benefits	Remarks
Existing Positions						
Laboratory Director	Rushing, D. F.	GS-15/4	18,825	18,825	1,368	
Administrative Aid	Zeman, Blanche	GS-6/6	6,662	6,662	490	
Clerk-Steno	Madsen, Janice	GS-4/4	5,109	5,148	433	
Supv. Chemist, Radiological Unit	Talvitie, N. A.	SHSO +20/GS-13	11,146	11,146	2,784	Detailed to FWPCA as C/O
Chemist, Analytical	Garcia, W. J.	GS-11/6P	10,797	10,797	819	
Chemist, Analytical	Demint, R. J.	GS-11/6P	10,797	10,797	819	
Chemist, Analytical	Clark, D. A.	GS-11/4P	10,185	10,185	779	
Physical Science Technician	Sorenson, B. C.	GS-5/2	5,352	5,524	379	Step increase 8/66
Physical Science Aid	Farmer, R. J.	GS-4/4	5,109	5,209	393	Step increase 1/67
Supv. Chemist, Inorganic Unit	Connor, J. C.	GS-13/4	13,815	14,085	1,043	Step increase 1/67
Chemist	Jarrell, R. E.	GS-12/4	11,723	11,723	882	
Chemist, Analytical	Freking, R. J.	GS-9/4P	8,749	8,749	680	Converts from C/O by 7/1/66
Chemist, Aralytical	Kiesler, H.	GS-9/6P	9,257	9,312	719	
Chemist, Analytical	Tauer, R.	GS-7/1P	7,304	7,379	591	Step increase 3/26/67
Chemist, Analytical	Vacant	GS-7/1P	7,304	7,304	586	
Chemist, Analytical	Smith, F. A.	GS-4/1	4,641	4,749	359	Step increase 11/11/66
Chemist, Analytical	Park, D. L.	GS-4/1	4,641	4,703	356	
			SUB-TOTAL	440,984	40,346	
			Less 5% for Turnover	22,049	2,017	
			TOTAL	418,935	38,329	457,264

ANALYSIS OF EXTERNAL EXPENSES
FY 1966 and FY 1967

April 1966

Region VIII, Denver, Colorado

Colorado River Basin Water Quality Control Project

Recipient	Description of Work	Method of Payment*	1966 Estimate	1967 Estimate
General Services Administration	Car and truck rental	R	$ 27,013	$ 26,500
General Services Administration	Telephone	R	5,000	5,700
Government Printing Office	Report reproduction	R	3,000	5,000
Private Individuals	Sample collection	P	5,062	5,000
Department of Agriculture	Economic Research Survey	R	47,500	25,000
U. S. Geological Survey	Stream measurement	R	2,450	1,500
University of Colorado	Economic study	C	52,000	25,000
GSA Computer Sharing Exchange	STORET and ADP	C	4,000	5,000
Private Individuals	Technical services	C	4,000	4,000
Various Firms	Supplies and services	P	22,764	22,036
Various Firms	Equipment	P	13,220	1,000
			$186,009	$125,736

* C - Contract
R - Reimbursement to other Federal Agency
P - Purchase Order

ANALYSIS OF 1966 VACANCIES

Region VIII, Denver, Colorado

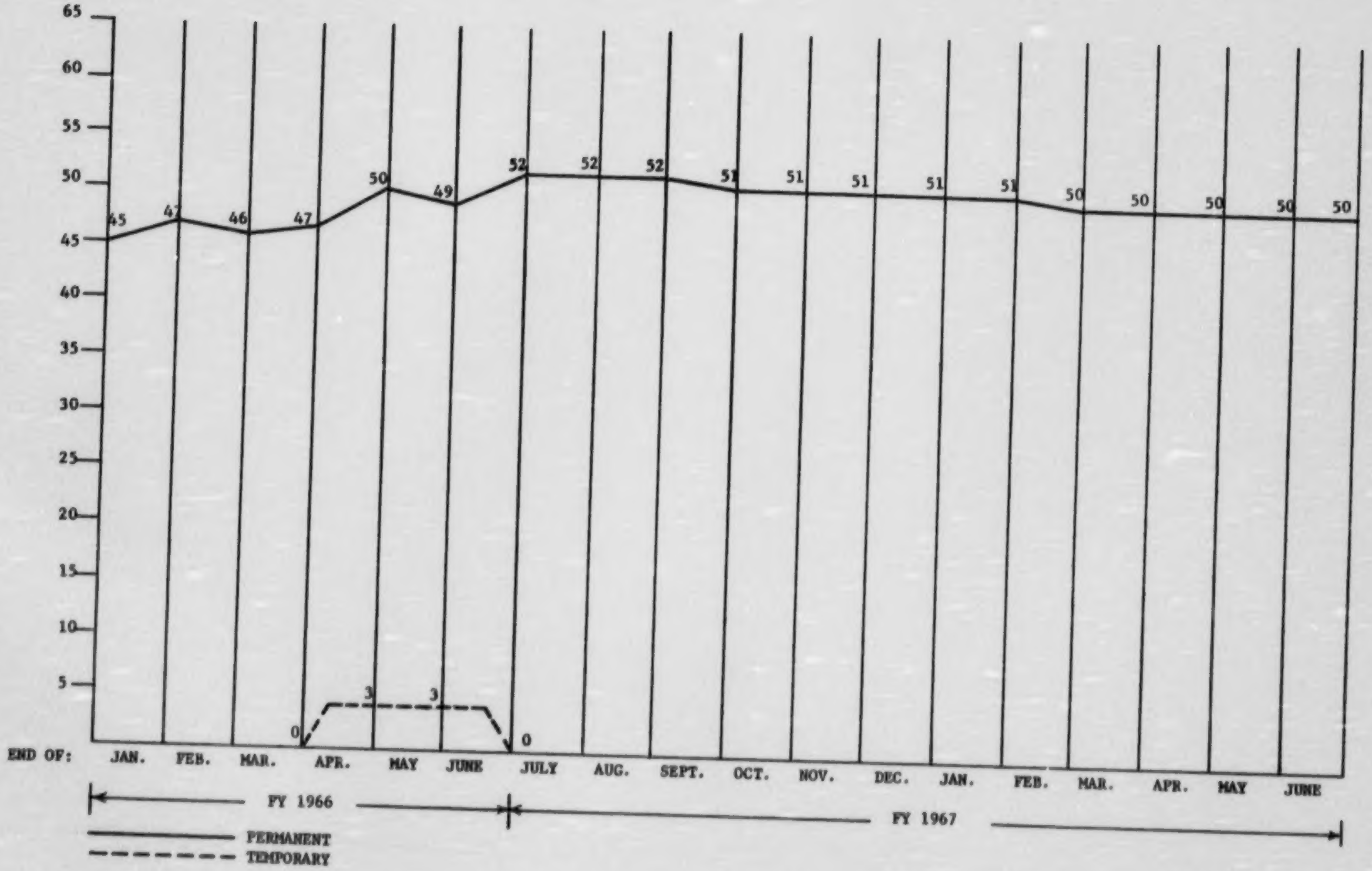
Colorado River Basin Water Quality Control Project

Total Number of Permanent Positions (Allowance)	52
Total Filled Positions as of April 1, 1966 (Actual)	47
Unfilled Positions as of April 1, 1966	5

Unit and Position Title	Grade or Rank	Series	Pos. No.	Duty Station	Candidate	Est. EOD	Recruitment Act. Requested	Remarks
Chief, Salinity Unit (Supv. Sanitary Eng.)	GS-13	819	--	Denver, Colo.	---	6/5/66	---	Classified.
Sanitary Engineer, Salinity Unit	GS-12	819	--	Denver, Colo.	Crabtree, R.	4/10/66	Yes	Appointment requested.
Sanitary Engineer, Salinity Unit	GS-11	819	--	Denver, Colo.	---	6/5/66	---	2 - GS-11 Sanitary Engineer positions not to be filled until anticipated transfers and terminations occur.
Sanitary Engineer, Salinity Unit	GS-11	819	--	Denver, Colo.	---	6/5/66	---	
Sanitary Engineer, Municipal & Industrial Unit	GS-9	819	--	Denver, Colo.	Clapper, T.	4/10/66	Yes	Appointment requested.
Chemist, Laboratory Section	GS-7	1320	266.1	Salt Lake City, Utah	---	6/5/66	Yes	Recruiting.
Physical Science Aid, Laboratory Section	GS-4	1311	205IA	Salt Lake City, Utah	Park, D. L.	4/10/66	Yes	Appointment requested.

PROJECTED MONTHLY EMPLOYMENT
Colorado River Basin Water Quality Control Project

April 1966



SUPPLIES AND EQUIPMENT AVAILABLE FOR TRANSFER
FY 1966 - 1967

April 1966

Region VIII, Denver, Colorado

Colorado River Basin Water Quality Control Project

Quantity	Item of Equipment	Trade Name	Condition	Date Available for Transfer	Remarks
1	Sterilizer, Autoclave	Barnstead	-	3-1-66	Fisher Cat. No. 0704
1	Refrigerator, 7 cu. ft.	-	very old, serviceable	3-1-66	-
4	Aquaria, 50 gal.	-	-	3-1-66	Glass and stainless steel
1	Sterilizer, hot air, therm. control	-	-	3-1-66	-
1	Demineralizer, dual bed	Ilco Model HB 460	-	3-1-66	-
24	Bottles, 5 gal.	-	-	3-1-66	Glass, widemouth
5	Tanks, 50 gal.	-	-	3-1-66	Polyethylene, round, w/lids & spigots
1	Sampler, water, 1200 ml	Foerst	-	3-1-66	-
1	Sampler, water, 3000 ml	Foerst	-	3-1-66	-
1	Sampler, bottom	Surber	-	3-1-66	-
4	Nets, plankton, tow	-	-	3-1-66	Fine and very fine
6	Nets, gill	-	new	3-1-66	1", 2", 3" mesh, 50 yds.
12	Seines, minnow	-	new and used	3-1-66	6, 10, 20, 30 ft.
	Dip nets	-	-	3-1-66	Round with handles

ANALYSIS OF EXISTING AND PROJECTED SPACE
FY 1966 - 1967

Region VIII, Denver, Colorado

April 1966

Colorado River Basin Water Quality Control Project

	Major Organizational Unit	Location	Utilization	Square feet	Estimated costs		Rent and/or utilities	Date of occupancy	Remarks
					1966	1967			
I.	PROJECT HEADQUARTERS	Bldg. 22, Denver Federal Center, Denver, Colorado	Office for Hdqtr. components-G	3,540	*	*	None	8-9-60	1/
II.	SALT LAKE CITY LABORATORY	1750 S. Redwood Rd., Salt Lake City, Utah	Office-G Lab-S	1,370 6,980	*	*	None	7-1-60	
III.	PHOENIX FIELD STATION	1320 N. First St., Phoenix, Arizona	Office-G	2,485	*	*	None	8-1-63	2/
IV.	FIELD DEPOT	Grand Junction, Colorado	Storage & workshop area & operations base for Upper Basin Sampling-G	1,000	$1,263		-	3-1-65	

G = General purpose
S = Special

* Property controlled by GSA. All operating and maintenance costs paid by GSA.

1/ An additional 2,100 sq. ft. space will be required to accommodate personnel of Pollution Source Evaluation Section when anticipated closing of Phoenix Field Station occurs.

2/ Space at Phoenix will not be necessary when personnel of Pollution Source Evaluation Section transferred to Denver Headquarters office.

SECTION C
APPENDICIES

APPENDIX A

COLORADO STATE DEPARTMENT OF PUBLIC HEALTH
4210 East 11th Avenue
Denver, Colorado

PROPOSED:

REGULATION PROVIDING THAT TAILINGS PILES FROM URANIUM AND THORIUM MILLS BE ADEQUATELY AND PROPERLY STABILIZED OR REMOVED

Whereas there are at divers places in the State of Colorado, tailings piles and wastes from uranium and thorium mills which may not be adequately covered, secured and impounded so as to prevent wind erosion which carries the fine particles of dust from the piles and distributes them over wide areas which in some instances include towns and populated areas, or to prevent water erosion from such piles from being carried into and possibly contaminating the streams and watercourses, and

Whereas the blowing dust from said mill tailings piles may constitute a nuisance to persons living in the areas affected thereby and adversely affect their health and well-being and the peaceful enjoyment of their homes and property; and the erosion thereof by both wind and water therefrom may pollute and contaminate streams and watercourses in the watersheds involved from which public water supplies are being obtained, and

Wherefore the board therefore finds that it is necessary for the proper protection of the public health and safety that appropriate action be immediately instituted to determine appropriate means and methods whereby such tailings piles be stabilized or removed to a more appropriate location, in order that the possibility of pollution of the air and waters of the state therefrom may be abated, and it is hereby declared to be the ORDER of the Colorado State Board of Health that the owners, operators and other persons or corporations having or claiming to have a legal interest in the premises where tailings piles from uranium or thorium mills are situated, or persons having responsibility for the operation of the mill, submit to the State Department of Public Health within thirty days after the effective date of this regulation a written report setting forth plans and measures employed by them to stabilize such tailings piles and what further plans and measures, if any, are proposed to accomplish the purposes of this regulation.

The effective date of this regulation will be thirty days from and after the date of adoption hereinafter set forth.

APPENDIX B

Proposed Outline

Report on

Pollution of the Colorado River and Its Tributaries

Volume I - Summary Report

Volume II - The Radiological Pollution Problem

  Appendix - Radiological Water Quality Data Obtained by Project

Volume III - The Mineral Pollution Problem

  Part A - Location and Magnitude of Salinity Sources

    Appendix - Water Quality Data Obtained by Project

  Part B - Statistical Analysis of Changes in Water Quality Relation to Time and Distance

    Appendix

  Part C - Analysis of Changes in Specific Constituents

    Appendix

  Part D - Nature and Magnitude of Direct Damages Due to Salinity

    Appendices

  Part E - Prevention and Control Measures

    Appendices

  Part F - Economic Benefits of Improved Water Quality

    Appendices

Volume IV - Municipal, Industrial, and Related Water Pollution Problems

  Appendices

Proposed Outline

Pollution of the Colorado River and Its Tributaries

Volume I

Summary Report

- I. Preface
- II. Table of Contents
  - A. List of Functional Parts of Body of Report
  - B. List of Tables
  - C. List of Figures
  - D. List of Appendixes
- III. Introduction
  - A. Authority for Project
  - B. Objectives and Scopes of Project
  - C. Acknowledgments
- IV. Conclusions
- V. Recommendations
- VI. General Description of the Basin
  - A. Geography
  - B. Topography
  - C. Climate
  - D. Hydrology
  - E. Economy

VII. Water Resources of the Basin

- A. Overall Importance of Water in Basin
- B. Development of Water Resources
    - 1. Present Status
    - 2. Plans for Future Development
- C. Division of Basin Water
    - 1. Between Upper and Lower Basins
        - a. Background Leading to Division of Water
        - b. The Colorado River Compact
    - 2. Between States
        - a. Upper Colorado River Basin Compact
        - b. Upper Colorado River Commission
        - c. Contracts by the United States with Arizona, Nevada, and California
        - d. Contract by the United States with Metropolitan Water District of Southern California
    - 3. Between United States and Mexico
        - a. Background
        - b. The Treaty with Mexico
        - c. Agreement Pertaining to Wellton-Mohawk By-pass Canal

VIII. Type and Scope of Water Pollution Investigations

- A. Radiological Pollution
    - 1. Studies of Radiological Pollution Problems Associated with Uranium Mining and Milling Operations
        - a. Liquid Wastes
        - b. Solid Wastes (Tailings Piles)
    - 2. Studies of Radiological Pollution Associated with World-wide Testing of Nuclear Weapons

B. Mineralization or Saline Pollution

1. Identification and Evaluation of Salinity Sources

   a. Review and Utilization of Existing Data

   b. Salinity Sampling Program of Project

2. Statistical Analysis of Changes in Water Quality in Relation to Time and Distance

3. Analysis of Changes in Specific Constituents

4. Salinity Damage Assessment Studies

   a. Rationale

   b. Water Quality Requirements for Various Uses

   c. Procedures for Assessing Damages to Water Users

   d. Evaluation of Damages

5. Salinity Control Studies

   a. Evaluation of Measures for Controlling Specific Sources of Salinity

      (1) Municipal and Industrial Sources

      (2) Irrigation

      (3) Natural Runoff

      (4) Saline Springs and Other Natural Sources

   b. Evaluation of Measures for Minimizing Salinity Concentrating Factors

      (1) Reducing Evaporation

      (2) Control of Phreatophytes

   c. Evaluation of Other Control Measures

      (1) Desalination

      (2) Importation of Water

- d. Economics of Water Quality Control (Direct)
  - (1) User Cost Curves
  - (2) Salinity Control Measures and Costs
  - (3) Water Quality Levels to Minimize User Costs (Damages)
- 6. Economic Studies (Direct and Indirect)
  - a. Interindustry Economic Base Study (1965, 1980, and 2010)
    - (1) Without Water Quantity and Quality Constraints
    - (2) With Water Quantity Constraints
    - (3) With Water Quantity and Quality Constraints
    - (4) Benefit-cost Analysis of Alternative Programs of Quality Control
- C. Other Pollution Problems
  - 1. Municipal Wastes
  - 2. Recreational Pollution
  - 3. Industrial Wastes
  - 4. Nutrients
  - 5. Pesticides
  - 6. Oil Pollution
  - 7. Sediment
  - 8. Waste Water from Federal Installations

IX. Summary of Findings

- A. Water Uses
  - 1. Irrigation Agriculture
  - 2. Stock Watering
  - 3. Municipal
  - 4. Industrial

    5. Power Generation by Steam and Hydroelectric Plants
    6. Fish and Wildlife
    7. Recreation
    8. Waste Disposal

B. Radiological Pollution
    1. Location and Magnitude of Sources
        a. Natural
        b. Uranium Industry
        c. Fall-out from Testing of Nuclear Weapons
    2. Effects on Water Quality and Water Uses
    3. Control of Radiological Pollution

C. Mineralization or Saline Pollution
    1. Location and Magnitude of Sources
        a. Natural Sources
            (1) Runoff
            (2) Saline Springs
            (3) Other Natural Sources
        b. Man-made Sources
            (1) Irrigation Agriculture
            (2) Municipal and Industrial
    2. Changes in Water Quality in Relation to Time and Distance
    3. Changes in Specific Constituents and Their Significance
    4. Effects of Increased Salinity Concentration on Water Users

5. Magnitude of Direct Salinity Damages (1965, 1980, 2010)
    a. Municipal Water Supply
    b. Industrial Water Supply
    c. Agricultural Water Supply
6. Measures and Programs for Minimizing Salinity Problems
    a. Control of Specific Sources (Including Estimates of Direct Costs)
        (1) Natural Sources
            (a) Runoff
            (b) Saline Springs and Other Natural Sources
        (2) Man-made Sources
            (a) Irrigation Agriculture
            (b) Municipal and Industrial
        (3) Factors Effecting Salinity Concentration
            (a) Irrigation Agriculture
            (b) Evaporation Reduction
            (c) Control of Phreatophytes
            (d) Deposition in Lakes and Streams
            (e) Exportation of Water
            (f) Importation of Water
        (4) Economics of Water Quality Control (Direct)
            (a) User Cost Curves
            (b) Salinity Control Measures and Costs
            (c) Water Quality Levels to Minimize User Costs

7. Interrelationships Between Economic Activity, Water Quantity and Water Quality
    a. Total Effects of Economic Activity on Water Quantity and Quality
        (1) Without Importation
        (2) With Importation
    b. Total Effects of Water Quantity and Quality on Economic Activity
        (1) Without Importation
        (2) With Importation
    c. Final Reconciliation of Water Quantity, Quality, and Economic Activity on Each Other
        (1) Without Importation
        (2) With Importation

D. Municipal Pollution
    1. Location and Magnitude of Sources
    2. Effects on Water Quality and Water Uses
    3. Control Programs

E. Recreation Pollution
    1. Location and Magnitude of Sources
    2. Effects on Water Quality and Water Uses
    3. Control Programs

F. Industrial Wastes
    1. Location and Magnitude of Sources
    2. Effects on Water Quality and Water Uses
    3. Control Programs

G. Nutrients
    1. Nature and Magnitude of Problem
    2. Effects on Water Quality and Water Uses
    3. Control Aspects

H. Pesticides
    1. Nature and Magnitude of Problem
    2. Effects on Water Quality and Water Uses
    3. Monitoring Program and Control Aspects

I. Oil Pollution
    1. Location and Magnitude of Sources
    2. Effects on Water Quantity and Uses
    3. Control Aspects

K. Sediment
    1. Nature and Magnitude of Problem
    2. Effects on Water Quality and Water Uses
    3. Control Aspects

X. Water Quality Objectives

XI. State Water Pollution Control Programs

PROPOSED OUTLINE

Pollution of the Colorado River and Its Tributaries

Volume II

The Radiological Pollution Problem

I. Preface

II. Table of Contents

III. Introduction

- A. Purpose and Scope of Investigations
- B. Acknowledgements

IV. Summary

- A. General Nature of the Problem
- B. Defining the Problem
- C. Control of the Problem

V. Conclusions

- A. Natural Radiological Pollution
  - 1. Springs in Glenwood Springs Area
  - 2. Dolores River between Slick Rock and Bedrock
- B. Radiological Pollution from World-wide Fallout
- C. Radiological Pollution from Uranium Mining and Milling Industry
  - 1. Liquid Wastes from Uranium Mills
  - 2. Solid Wastes from Uranium Mills (Tailings Piles)
  - 3. Uranium Mines

VI. Recommendations

- A. Liquid Wastes from Uranium Mills
- B. Solid Wastes from Uranium Mills

VII. History of Uranium Mining and Milling Industry in the Colorado River Basin

VIII. Uranium Milling Wastes

IX. Previous Radiological Pollution Investigations in the Colorado River Basin

X. Radiation Exposure Philosophy

  A. International Commission on Radiological Protection and the Federal Radiation Council

  B. National Bureau of Standard Handbooks 52 and 69

  C. Atomic Energy Commission Regulation 10 CFR, Part 20

XI. Aspects of Radiological Pollution Control

  A. Criteria and Design of Control Measures at Uranium Mills

  B. Implementation of Control Measures

XII. Methods of Investigation

  A. Field Investigations

    1. Stream Surveys in the Vicinity of Uranium Mills

    2. Mill Effluent Sampling

    3. Tailings Piles Studies

    4. Water Sampling (RMN)

    5. Sediment Sampling

      a. Basinwide Surveys

      b. Special Surveys

        (1) Dolores-San Miguel River

        (2) Monticello Study

        (3) Lake Mead Studies

    6. Biota Sampling

    7. Crop and Soil Studies

  B. Analytical Methods

XIII. Presentation and Interpretation of Findings
    A. Field Investigations
        1. Stream Surveys in the Vicinity of Uranium Mills
        2. Mill Effluent Sampling
        3. Tailings Pile Studies
        4. Water Sampling (RMN)
        5. Sediment Sampling
            a. Basinwide Surveys
            b. Special Surveys
                (1) Dolores-San Miguel River
                (2) Monticello Study
                (3) Lake Mead Studies
        6. Biota Sampling
        7. Crop and Soil Studies

XIV. Bibliography

XV. Appendix - Radiological Water Quality Data Obtained by the Colorado River Basin Water Quality Control Project

Proposed Outline

Pollution of the Colorado River and Its Tributaries

Volume III

Part D

Nature and Magnitude of Direct Damages Due to Salinity

I. Table of Contents

II. Introduction

    A. Objectives of Study

    B. Rationale for Salinity Damage Assessment

    C. Acknowledgments

III. Summary of Findings

    A. Conclusions

    B. Recommendations

IV. Water Quality Requirements*

    A. General Classification of Water Pollutants

    B. Municipal and Domestic Supply

    C. Industrial Supply

    D. Agricultural - Irrigation and Livestock

    E. Game Fish

    F. Ground Water Replenishment

V. Methods of Damage Assessment

    A. Definition of Damages and Benefits

    B. Derivation and Use of Water Quality Bases

    C. Salinity Damage Assessment

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* We shall emphasize mineral quality in this report.

    1. Municipal Supply
    2. Industrial Supply
    3. Irrigation
    4. Ground Water Replenishment
    5. Recreation and Wildlife Habitat

VI. Evaluation of Damages
  A. Distribution of Salinity Damages
  B. Lower Main Stem Subbasin
  C. Southern California Water Service Area
  D. Central Arizona Project Area
  E. Other Areas
  F. Summary of Salinity Damages

VII. Economics of Water Quality Control
  A. User Cost Curves
  B. Salinity Control Measures and Costs
  C. Water Quality Levels to Maximize Economic Benefits

VIII. Bibliography

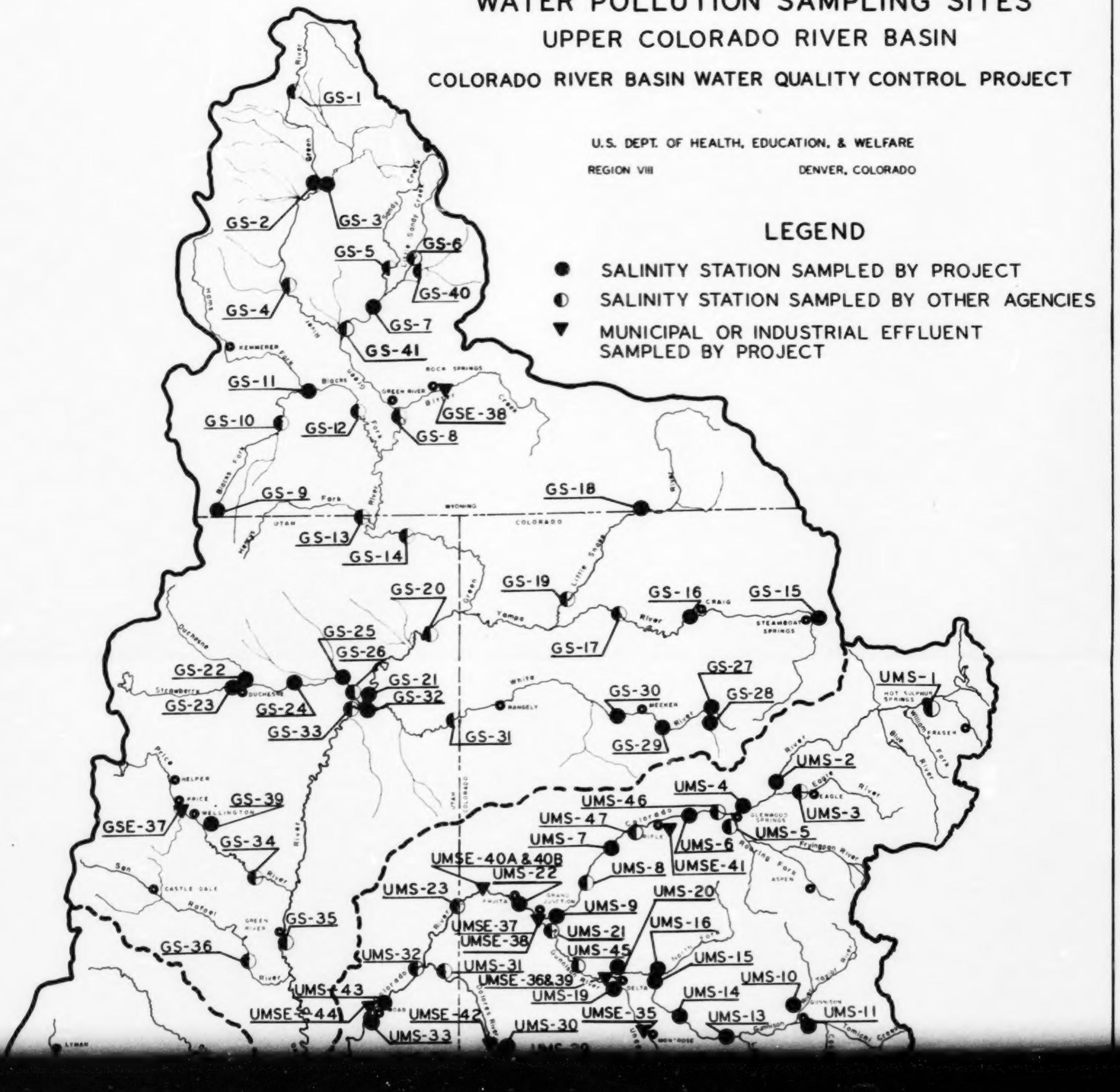
IX. List of Tables

X. List of Figures

XI. Technical Appendixes

WATER POLLUTION SAMPLING SITES
UPPER COLORADO RIVER BASIN
COLORADO RIVER BASIN WATER QUALITY CONTROL PROJECT

U.S. DEPT. OF HEALTH, EDUCATION, & WELFARE
REGION VIII DENVER, COLORADO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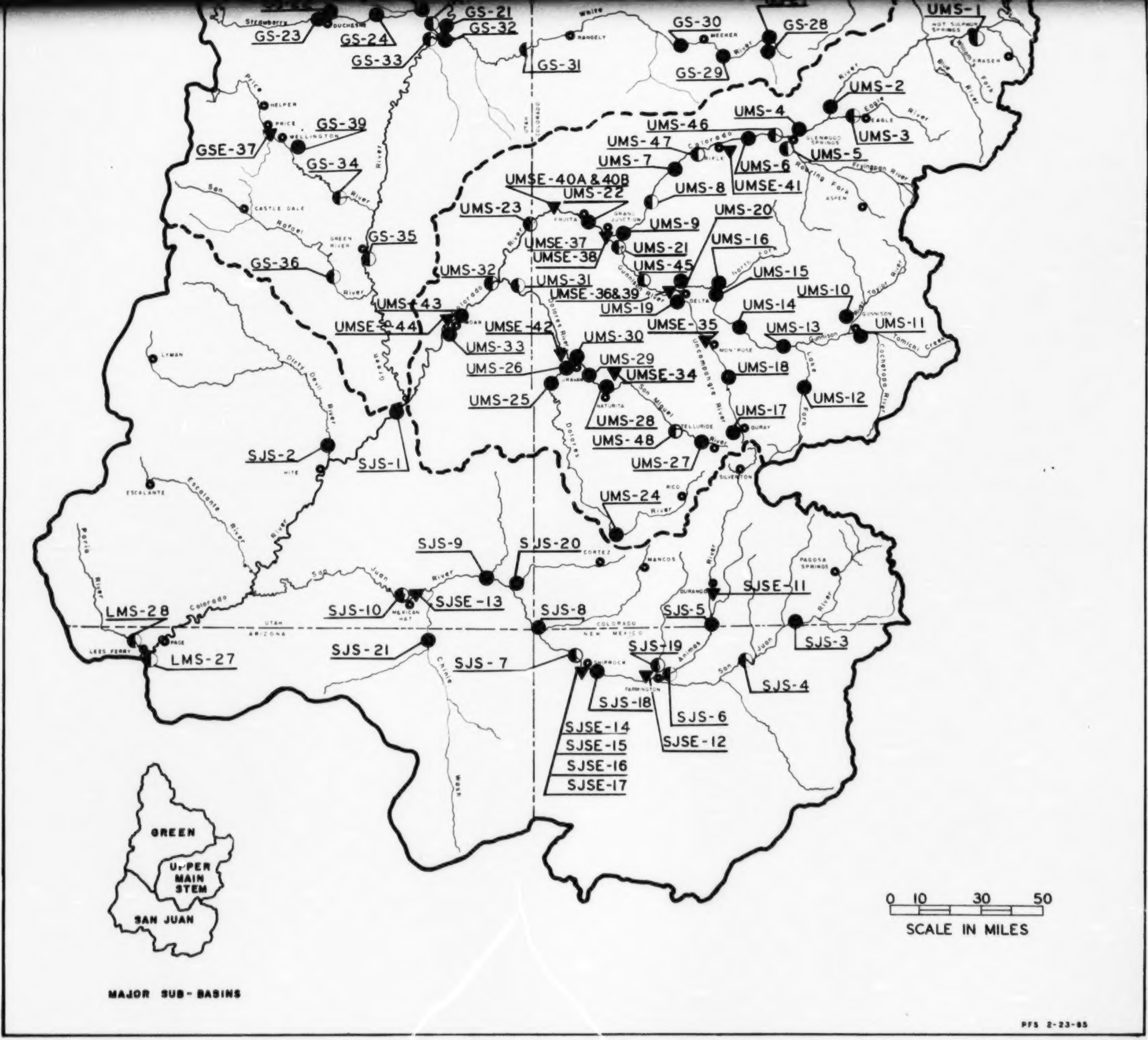
UMS-47
UMSE-35
UMSE-36&39
UMSE-37
UMSE-38
UMSE-40A & 40B
UMSE-41
UMSE-42
UMSE-44
Green River
Hams Fork
Kemmerer
Biggs Fork
Green River
Rock Springs
Bitter Creek
Sandy Creek
Utah
Wyoming
Colorado
Yampa
Little Snake
Craig
Steamboat Springs
Duchesne
Strawberry
White
Rangely
Meeker
Price
Helper
Wellington
San Rafael
Castle Dale
Hot Sulphur Springs
Williams Fork
Fraser
Blue River
Eagle River
Eagle
Glenwood Springs
Colorado
Rifle
Roaring Fork
Frying Pan River
Aspen
Fruita
Grand Junction
Gunnison River
Delta
Montrose
Dolores River
Taylor River
Tomichi Creek
Lyman

LEGEND

● SALINITY STATION SAMPLED BY PROJECT
◐ SALINITY STATION SAMPLED BY OTHER AGENCIES
▼ MUNICIPAL OR INDUSTRIAL EFFLUENT SAMPLED BY PROJECT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LMS-27
Strawberry
Duchesne
White
Rangely
Meeker
River
Hot Sulphur Springs
Williams Fraser
Blue River
Fork
Eagle River
Eagle
Glenwood Springs
Colorado
Rifle
Roaring Fork
Frying Pan River
Aspen
Fruita
Grand Junction
Gunnison River
North Fork
Delta
Taylor River
Gunnison
Tomichi Creek
Cochetopa River
Montrose
Uncompahgre River
Lake Fork
Dolores River
Gateway
San Miguel
Naturita
Telluride
Ouray
Silverton
Rico
Dolores
Cortez
Mancos
Durango
Animas
Pagosa Springs
San Juan River
Farmington
Shiprock
Mexican Hat
Chinle Wash
Price
Helper
Wellington
San Rafael
Castle Dale
Green River
Moab
Dirty Devil River
Hite
Lyman
Escalante
Escalante River
Paria River
Lees Ferry
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Utah
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UPPER MAIN STEM
SAN JUAN
MAJOR SUB-BASINS
0 10 30 50
SCALE IN MILES
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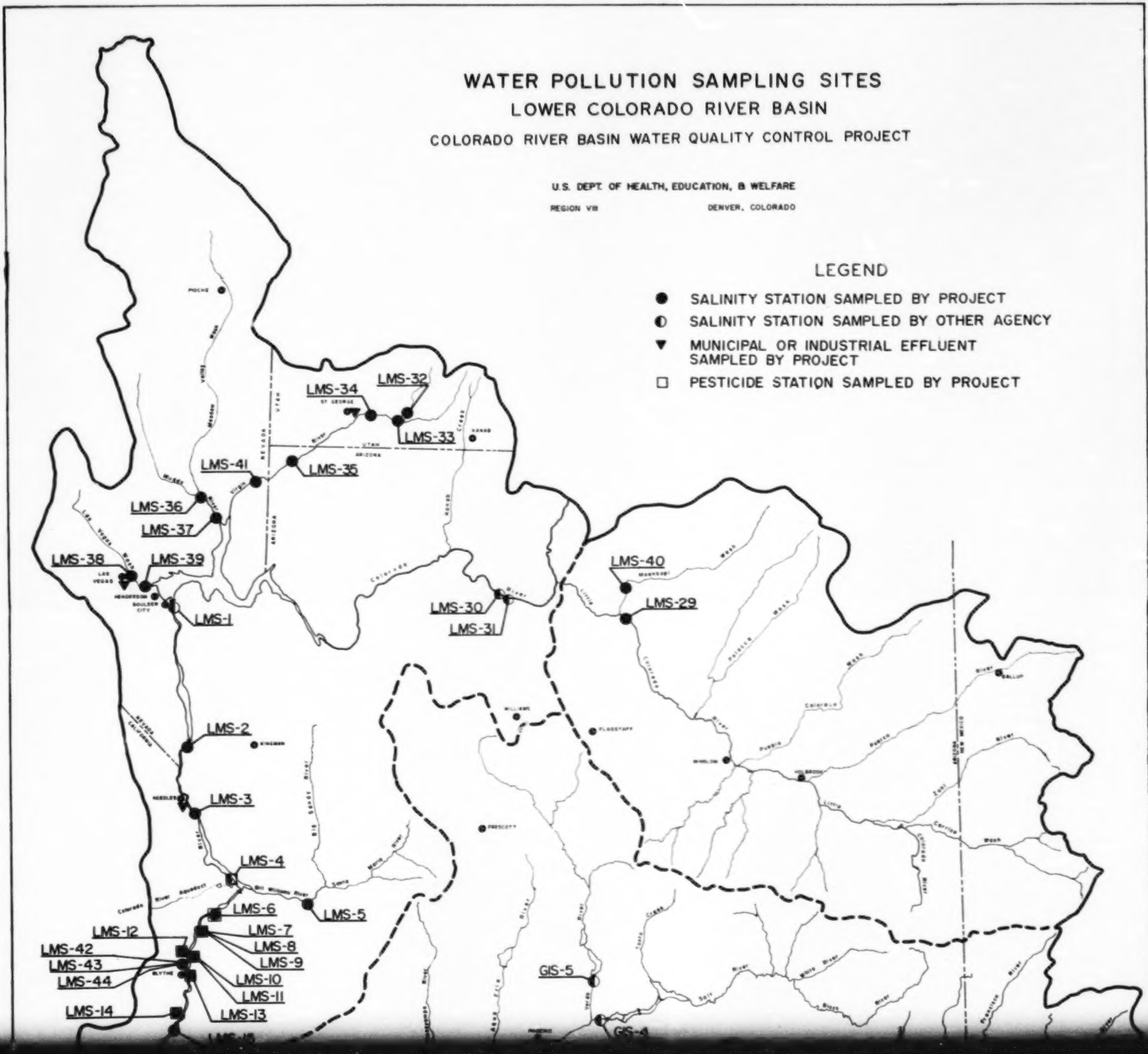

WATER POLLUTION SAMPLING SITES

LOWER COLORADO RIVER BASIN

COLORADO RIVER BASIN WATER QUALITY CONTROL PROJECT

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DENVER, COLORADO

LEGEND

- ● SALINITY STATION SAMPLED BY PROJECT
- ◐ SALINITY STATION SAMPLED BY OTHER AGENCY
- ▼ MUNICIPAL OR INDUSTRIAL EFFLUENT SAMPLED BY PROJECT
- ☐ PESTICIDE STATION SAMPLED BY PROJECT

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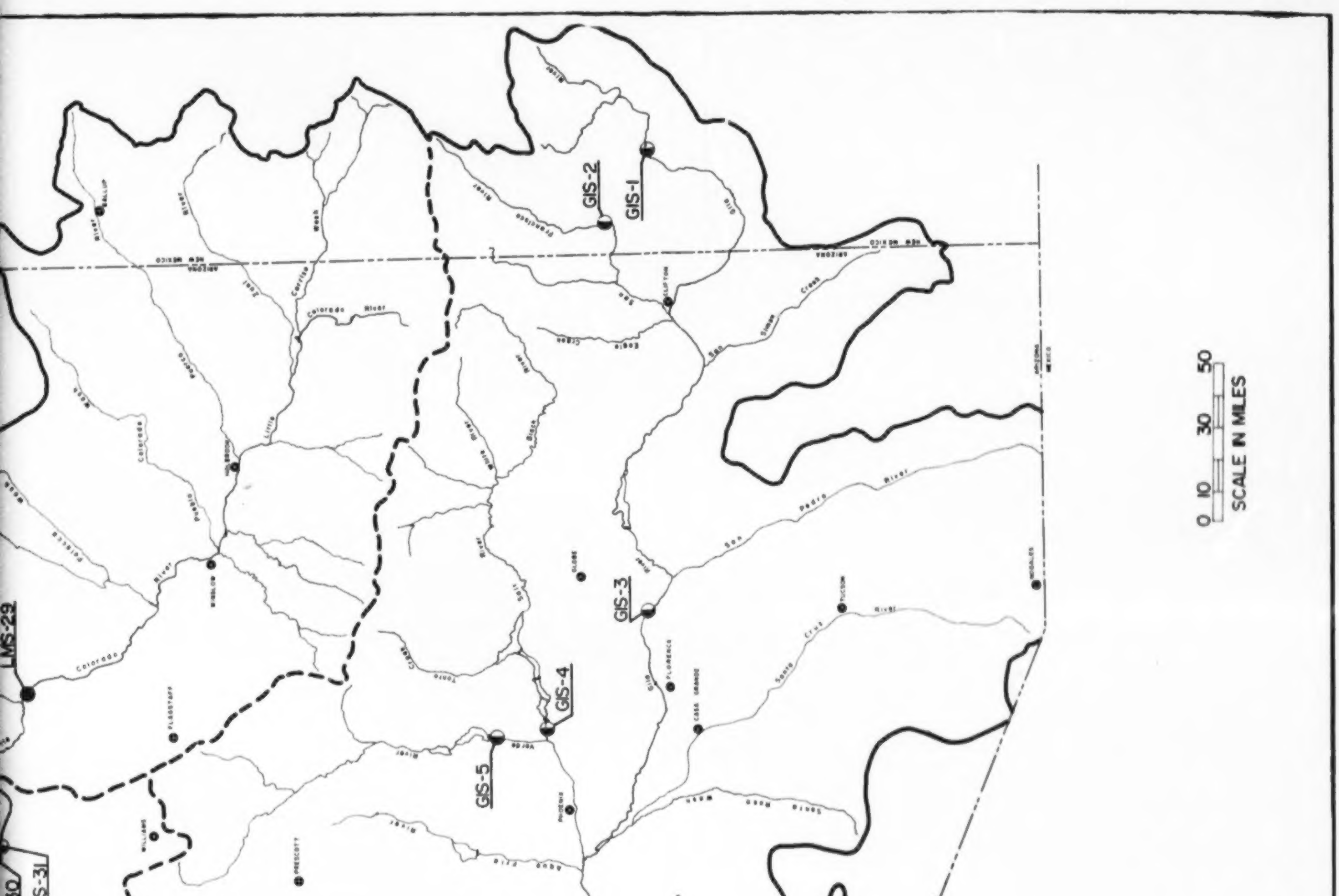
LMS-43
LMS-44
GIS-4
GIS-5
PIOCHE
ST GEORGE
KANAB
LAS VEGAS
HENDERSON
BOULDER CITY
KINGMAN
NEEDLES
BLYTHE
WILLIAMS
FLAGSTAFF
PRESCOTT
WINSLOW
HOLBROOK
GALLUP
PHOENIX
UTAH
NEVADA
ARIZONA
CALIFORNIA
NEW MEXICO
Colorado River
Virgin River
Muddy River
Meadow Valley Wash
Las Vegas Wash
Kanab Creek
Little Colorado River
Moenkopi Wash
Bill Williams River
Santa Maria River
Big Sandy River
Colorado River Aqueduct
Verde River
Salt River
Tonto Creek
White River
Black River
Zuni River
Puerco River
Carrizo Wash
Agua Fria River
Hassayampa River
San Francisco River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SCALE IN MILES
SAN JUAN
GILA
LOWER MAIN STEM
MAJOR SUB-BASINS
ARIZONA
NEW MEXICO
MEXICO
NEVADA
CALIFORNIA
Gila River
San Simon Creek
San Pedro River
Santa Cruz River
Salt River
Verde River
Agua Fria River
Hassayampa River
Big Sandy River
Little Colorado River
Puerco River
Zuni River
Black River
Tonto Creek
Santa Rosa Wash
Eagle Creek
Carrizo Wash
San Francisco River
Colorado River
GALLUP
CLIFTON
GLOBE
TUCSON
FLORENCE
CASA GRANDE
PHOENIX
NOGALES
FLAGSTAFF
WILLIAMS
PRESCOTT
KINGMAN
NEEDLES
BLYTHE
GILA BEND
AJO
WINSLOW
HOLBROOK

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